

The Nesting Ecology of Cooper's Hawks
and Northern Goshawks in the Jemez
Mountains, New Mexico 1984 Results

by Patricia L. Kennedy

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INTRODUCTION

In recent years, many raptor populations have declined throughout the U.S. Precise relationships between most man-induced impacts and raptor populations are poorly understood and documented. A desire to minimize the effects of man-induced impacts on raptor populations has placed a premium on knowledge of the specific ecological requirements of the potentially affected species.

Two raptor species that are sensitive indicators of environmental contamination are the Cooper's Hawk (Accipiter cooperii) and the Northern Goshawk (A. gentilis). The Cooper's Hawk is a common raptor throughout the Southwest (Snyder et. al., 1973; Millsap 1981). It inhabits a wider variety of habitats than the Sharp-shinned Hawk (A. striatus) or Northern Goshawk and is generally considered a lower elevation bird. The association of Cooper's Hawks with riparian habitats in canyons is well-documented (Hubbard 1978; Jones 1979). Millsap et. al. (1980) reported that livestock grazing has probably caused population declines of the Cooper's Hawk in Arizona. They hypothesized that grazing reduced the Cooper's Hawks' prey populations via habitat destruction. In addition, timber harvest and other timber management techniques may impact the availability of nest sites. Due to the potential impact of grazing and timber management on this species, it is listed as a sensitive species by the Southwestern Region of the U.S. Forest Service.

Not only is the Cooper's Hawk sensitive to habitat changes, it is also susceptible to contamination from pesticides. Over much of the Cooper's Hawk's range, DDE levels have been noted in eggs, and associated egg breakage has apparently reduced productivity below stable population levels in some instances (Henny and Wight 1972; Snyder et. al. 1973). Snyder et. al. (1973) demonstrated a significant relationship between the percent of birds in the diet of Cooper's Hawks nesting in southern Arizona and New Mexico, and the levels of DDE in the eggs of these pairs. They concluded that southwestern Cooper's Hawks showed signs of DDE stress.

The Northern Goshawk is rare to uncommon in the Southwest (Hubbard 1978; Millsap 1981). Throughout its range, the Northern Goshawk nests primarily in dense, mature, or old growth coniferous forest (Bent 1937; Bull 1978; Hubbard 1978; Reynolds et. al. 1982). Because of the Northern Goshawks' dependency on mature, montane forests for nest sites it is threatened not only by loss of forest habitat which is

occurring throughout the U.S., but also by recent trends toward shorter rotation periods in timber management (Snyder and Snyder 1975). In Great Britain, it appears that the Northern Goshawk is threatened by a lack of sufficient acreage of mature forest (Newton 1972). Northern Goshawk populations in the U.S. are increasing in the eastern states in second growth timber, although in most cases it is in the most mature stands (Snyder and Snyder 1975). With shorter rotation periods it is as yet unclear that this species can adapt and survive in areas managed for timber, unless tracts are set aside specifically for their management (Jones 1979).

Although the Cooper's Hawk and Northern Goshawk appear to be sensitive to land management practices and environmental pollution, their use as indicator species is limited because their ecologies and habitat tolerances are poorly understood. This severely hampers the agencies responsible for protecting these animals and their habitats. Quantitative baseline data are needed on the ecological requirements of these species particularly in southwestern habitats. Data on the ecological requirements of these species will allow land managers to develop management plans that will minimize the impact of their practices on these species and other wildlife with similar habitat requirements, e.g., Spotted Owl (Strix occidentalis), Long-eared Owl (Asio otus).

Quantitative baseline information is available on the nest-site habitat (Titus and Mosher 1981; Reynolds et. al. 1982; Moore and Henny 1983), nesting season diet (Storer 1966; Sherrod 1978; Reynolds 1979; Kennedy 1980) and productivity (Craighead and Craighead 1956; Henny and Wight 1972; Reynolds 1975; Kennedy 1980) of Cooper's Hawks and Northern Goshawks in the northeastern and northwestern U.S. The only published, quantitative data on the nesting ecology of southwestern Cooper's Hawks is reported by Snyder et. al. (1973), Snyder and Wiley (1976) and Millsap (1981). These studies were conducted in southeastern Arizona, southwestern New Mexico, and westcentral Arizona, respectively. These studies provide limited information on the diet during the breeding season, population density, productivity, and habitat surrounding the nest sites of the two species. No published data are available on the nesting ecology of these species in central or northern New Mexico and published data on habitat utilization patterns, activity patterns and home range size is not available for these two species at any location in their range.

I initiated a study of the nesting ecology of Northern Goshawks and Cooper's Hawks in the Jemez Mountains in northern New Mexico during 1984. This is a good study area

for collecting baseline ecological data on these two accipiters because it is intensively managed as a multiple-use area. The two species are nesting in areas subject to intensive timber, grazing and/or recreation management practices. In addition, data is being collected on the degree of niche overlap between the two sympatric species, which has been examined in sympatric populations in the northwest (Moore and Henny 1983; Reynolds and Meslow 1984) but not in the southwest.

This study is part of my Ph.D. dissertation research and was initiated in 1984 and will continue through the 1985 and 1986 field seasons. The 1984 field season was supported by Share With Wildlife and U.S. Forest Service, Santa Fe National Forest funding. This report presents the results of the 1984 field season.

OBJECTIVES

The objectives of this 3-yr study are to

- determine the distribution and numerical status of the Northern Goshawk and Cooper's Hawk in the Jemez Mountains, N.M., and evaluate population trends,
- determine the types of nesting habitat occupied by the Northern Goshawk and Cooper's Hawk,
- describe the life history of the species, including home range characteristics, reproductive biology, diet, and activity patterns, and
- develop specific management recommendations for the Northern Goshawk and Cooper's Hawks in the Jemez Mountains, based on the information obtained.

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Lastly I am deeply grateful to George Rinker who wrote the computer data analysis code and provided endless moral support and encouragement and tolerated all the inconveniences caused by my field schedule.

STUDY AREA

The study area included the Jemez Mountains, N.M. and the Pajarito Plateau, a table-like extension of the eastern flank of the Jemez Mountains. Most field work was conducted within a 20-mile radius of Los Alamos County, N.M. The Jemez Mountains and the Pajarito Plateau are located in north-central New Mexico, west of Santa Fe. The majority of the study area was on the Santa Fe National Forest. However, U.S. Department of Energy (DOE), U.S. Park Service and San Ildefonso property were also included in the study area.

The landscape on the study area is generally mountainous with numerous river valleys, mesas, and plateaus. Elevations range from 5,500 ft to 11,561 ft. The Jemez Mountains are characterized by steep, narrow canyons separated by gentle to moderately steep mesas.

Depending on the elevation, the amount of precipitation ranges from 8 to 35 in. annually with the majority falling in the summer months. The growing season ranges from 80 to 160 days per year, depending on elevation. The average annual temperature is 48°F (Potter et al. 1982).

Due to the varying climate, elevation, and soils of the area, the vegetation is diverse. Plant communities range from Cottonwood-Willow River Bottoms and Pinon-Juniper Woodlands at the lower elevations to Ponderosa Pine, Mixed Conifer, and Englemann Spruce/Subalpine Fir forests at the higher elevations.

A wide variety of timber stand age classes is found within the study area. Due to natural succession and man's influence, large areas are covered with trees in several age classes. Some of these stands, particularly in the Ponderosa Pine forests, have an overstory made up of mature or old growth trees and a vigorous understory of pole or sapling-sized trees (U.S.F.S. 1983).

The majority of the study area (Santa Fe National Forest) has been used for generations for a variety of activities including: logging, fuelwood gathering, grazing, recreation, and religious ceremonies. The U.S. Park Service property on the study area (Bandelier National Monument) is managed for wilderness and recreation. The DOE and San Ildefonso properties do not allow public access.

METHODS

LOCATION OF NESTS

Searches for Northern Goshawk and Cooper's Hawk nests were initiated May 1, 1984 and May 15, 1984, respectively. These are the approximate average starting dates for incubation in both species. Nest searches continued until the early fledgling dependancy period (mid to late July 1984).

Nest searches were concentrated in areas where repeated sightings of Accipiters occurred or in areas containing prey "plucks" characteristic of Accipiters. Attempts were also made to search in potential timber sale areas identified by the U.S. Forest Service, Santa Fe National Forest personnel. Data on these areas can provide information to the Forest Service that can be used in planning their timber sales to minimize logging impacts on these two sensitive species.

Information provided by individuals mentioned in the Acknowledgements often led to nest discoveries.

RADIOTELEMETRY DATA COLLECTION AND ANALYSIS

Field Methods

Home range size, and activity patterns were determined from observations of radio tagged birds. Nesting pairs were trapped early in the nestling period (June) and fitted with posture-monitoring transmitters made by Biotrack. Adults were trapped at the nest with Dho-gaza nets and a live Great Horned Owl (Bubo virginianus). Standard morphometric measurements were taken from each trapped bird and all nestlings that were banded.

Radio transmitters were placed on three adult female Northern Goshawks, one adult male Northern Goshawk, three adult female Cooper's Hawks, and three adult male Cooper's Hawks. At one Northern Goshawk nest and three Cooper's Hawk nests, transmitters were placed on both members of a pair. At two of the three Goshawks nests transmitters were placed on the female but the males were not captured.

A Biotrack transmitter was attached dorsally to the central tail feathers and weighed approximately 6-8g. The posture-monitoring transmitter emitted a slow pulse rate when the bird's tail was vertical, e.g., a resting bird, a fast rate when the bird's tail was horizontal during flight or brooding, and an alternating rate when feeding, plucking, or preening (Kenward et al. 1982). Prey capture and handling could generally be identified by a continual erratic signal followed by a direct flight to the nest. The transmitters were tested for potential error in assigning activities based on signal patterns by monitoring trained falconer's birds equipped with transmitters. With practice, the error is negligible.

Transmitters operated for 1-86 days before they either stopped transmitting or were molted by the birds with the central tail feathers. Transmitter frequency was 150-151 Mhz. Radio receiving equipment included an AVM Model LA 12 receiver, a Biotrack receiver and two, hand-held, 3-element, yagi antenna. Because the second receiver did not arrive until the third week in July, the location of a bird was determined using two different techniques.

With one receiver, to determine the location of a bird by triangulation, the observer obtained a bearing with the hand-held antenna, then moved down the road or trail to obtain an additional bearing. If the bird moved before the second bearing was determined, a new series of bearings was obtained as soon as movement ceased. Movement could be detected from changes in the signal frequency resulting from the activity switch. The problem of Accipiters moving before a location could be determined was major because of the manner in which the Accipiters foraged during the nesting season. Except for females that remained near the nest during the early nestling period, the hawks rarely perched for long periods of time. Therefore, few accurate fixes were obtained until late July when we received the second receiver.

With two receivers, signals were monitored simultaneously by two observers each equipped with a receiver and a 3-element yagi antenna. The simultaneous tracking of the radio tagged birds provided more triangulated fixes on the birds locations which were much more accurate than the fixes that could be obtained by one observer.

Each bird was radio tracked continuously for 4-hr sampling periods systematically selected from four periods of the day, 05:00-09:00, 09:00-13:00, 13:00-17:00, and 17:00-21:00 (MST).

During each sampling period, the location of each observer was plotted on 7.5 U.S.G.S. topographic maps and the compass position (in relation to magnetic North) of the bird from each observer was recorded. In addition, all visual observations of radio-tagged birds were plotted on the maps.

Activity durations were registered with a stopwatch to the nearest second. Four types of activities were recognized: flight, perching, brooding (a continual fast signal at the nest; no change in bird position) and erratic. The erratic category included plucking, feeding, and eating. These could not be distinguished in the field. The amount of time during a sampling period in which a bird could not be located was also recorded.

Data Analyses

We developed a computer code, FIXX, to conduct the home range analyses of the radio-tracking data. We developed our own code rather than use available programs because no known program calculates error estimates for the predicted home ranges. In

most home range studies, home range estimates are presented with no estimate of the measurement error associated with the equipment used for collecting the radio-fixes of individual birds. For example, the accuracy of locations with the equipment used in this study declines as the distance between the observer and signal source increased. Based on tests with trained falconer's birds we determined there was, on the average, a 5° angle error associated with the measurement equipment. These equipment limitations were incorporated into FIXX to provide realistic assessments of the potential home ranges of the birds. The method for calculating the measurement error of each radio fix and the home range estimates is outlined below.

The following information was input data for FIXX.

- bird number,
- x, y coordinates of observer location,
- a two digit code identifying the U.S.G.S. 7.5 minute quadrangle on which the observer was located,
- the measurement angle of the bird's position in relation to each observer,
- map scale,
- date,
- time,
- activity type, and
- activity duration.

The minimum convex polygon method was used to calculate home range areas (Jennerich and Turner 1969). The home range was defined as the area used by an individual bird during the nesting season.

The error analysis generated by FIXX is a measurement error analysis not a sampling error analysis. Sampling error arises from the fact that a set of observations made of a parameter may not be representative of its true distribution. These errors are dealt with by primarily statistical techniques. Statistical analyses of the distribution of radio-fixes have not yet been incorporated into FIXX. Measurement error arises from the fact that a given observation may itself be inaccurate because of difficulties with apparatus or technique. These errors may be dealt with by analytical means, given some assumptions about errors in the primitive measurements.

In the minimum convex polygon estimate the area A of a convex polygon with n vertices at $(x_1, y_1) \dots (x_n, y_n)$ in counterclockwise order is

$$A = \frac{1}{2} \sum_{i=1}^n (x_{i-1}y_i - y_{i-1}x_i) ,$$

where

$$x_0 = x_n \text{ and } y_0 = y_n.$$

We take the measurement error of this polygon to be given by

$$(\delta A)^2 = \sum_{i=1}^n \left[\left(\frac{dA}{dx_i} \delta x_i \right)^2 + \left(\frac{dA}{dy_i} \delta y_i \right)^2 \right] ,$$

where δx_i and δy_i are the estimated uncertainties in the coordinates of the i^{th} vertex. This vertex is determined by triangulation from two points (x_a, y_a) and (x_b, y_b) with observation directions θ_a and θ_b . The observation points are assumed to be determined with no uncertainty. The error in x_i is then

$$(\delta x_i)^2 = \left(\frac{dx_i}{d\theta_a} \delta \theta_a \right)^2 + \left(\frac{dx_i}{d\theta_b} \delta \theta_b \right)^2 ,$$

with a corresponding expression for y_i .

This approach thus assumes in two steps that all errors are statistically independent and add incoherently. It neglects cross terms which would arise in an expression for $(\delta A)^2$ related directly to the primitive errors $\delta \theta_a$ and $\delta \theta_b$ for each fix (x_i, y_i) . We do not consider these cross terms to be particularly meaningful and have adopted the above approach because it is convenient and consistent with the remainder of our analysis of the bird positions.

DIET DETERMINATION

Accipiters regularly remove pelage and plumage from their prey in the nesting area or on the nest itself. These hawks regurgitate pellets, and, although most of the bone is digested, keratinized parts are not. On each visit to a nest site, all remains and pellets found in plucking areas or on nests were completely picked up. Nests received 4-6 visits

per month on the average. During identification, all remains in a day's collection were lumped and reconstructed by matching the remiges, rectrices, and bills of birds, and the fur, skull parts, and feet of mammals. This procedure minimized the possibility of over-counting the number of individuals of each species. Feather identification was based on comparison with the New Mexico Department of Game and Fish feather reference collections. Taxonomic keys to mammal guard hairs and reference slides of guard hairs of local mammals were used to identify the mammal fur. The analysis of casting remains is not yet completed because of the time-consuming nature of this process. Therefore, the results of the dietary analysis presented in this report focuses on the plucks which are predominantly avian prey species. A complete listing of prey taxa will be presented in subsequent reports.

Limitations of the Diet Data

Diets of raptors have been commonly determined from prey remains (Opdam 1975, Opdam et al. 1977, Boshoff and Palmer 1980; Newton and Marquiss 1982; Reynolds and Meslow 1982) but the method is not entirely free of bias (Snyder and Wiley, 1976). Høglund (1964) found differences between prey from nest sites and those from stomachs. Snyder and Wiley (1976) found that collections of remains and pellets from nests gave biased estimates of the diets of the Red-shouldered Hawks (Buteo lineatus). Schipper (1973) showed that birds and mammals are underestimated in prey remains of harriers (Circus sp.).

Additionally, plucks and nest remains may be biased toward the larger species. Smaller prey may be consumed by the adults away from the nest or delivered to the nest completely plucked. Therefore, the diet data presented here probably represents only a portion of the species consumed by the Accipiters. The extent and direction of the bias in our collections is unknown, because we did not make extensive observations at the nest. Nest observations will be initiated in subsequent field seasons.

HABITAT EVALUATION

Accipiter nest sites are defined as the forest stand containing the nest tree, including both the structural features of the vegetation, e.g., tree density, and the land form, e.g., slope, aspect within an area used by a pair and their fledglings during the nesting seasons (Reynolds et al. 1982). Thus the boundaries of the nest site for habitat

evaluation were determined by observations of the movements of adults and fledged young near the nest as well as the locations of prey plucking areas and roosts. Hunting areas e.g., areas not used by fledglings, areas not containing roosts, were not included in the nest site.

The nest sites in this study were approximately 6 ha for the Cooper's Hawk and 8-10 ha for the Northern Goshawk. This is comparable to the size of *Accipiter* nest sites in the northwest (Reynolds 1983).

Data on the following nest tree characteristics were collected at active Northern Goshawk and Cooper's Hawk nests located during 1984.

- Nest tree species,
- Nest tree dbh,
- Nest tree height,
- Nest height,
- Nest tree morphology,
- Distance from water, and
- Nearest distance to a human disturbance, e.g. house, road, campground, and type of disturbance.

The nest site was characterized using standard U.S. Forest Service silvicultural examination techniques as presented in the Silvicultural Examination and Prescription Handbook (FSH 2409.26d R-3).

Data on the following nest stand parameters were collected

- Tree density by species, size class, and timber inventory class,
- Snag density,
- Basal area,
- Aspect,
- Slope, and
- Average stand elevation.

Aspect and elevation were obtained from U.S.G.S. 7.5 minute quadrangles. Slope was measured with a clineometer. The timber parameters were measured in 9-10 plots

within each nest stand. The distribution of the plots was centered around the nest tree. One plot included the nest tree and the remaining plots were separated by a minimum of 20m (this varied depending upon the size of the nest site) and were located along transects located north, south, east, and west of the nest tree.

The field data collected at each stand was incorporated into the silviculture data base for Santa Fe National Forest timber stands. The timber inventory analysis of the nest stands was conducted by the U.S. Forest Service with their timber stand inventory computer code. By incorporating the nest stand data into the Forest data base, potential Northern Goshawk and Cooper's Hawk nest stands can be readily identified throughout the Santa Fe National Forest.

RESULTS

TAXONOMY

Northern Goshawks

Two subspecies of Northern Goshawks occur in New Mexico; Accipiter gentilis atricapillus and A.g. apache (Apache Goshawk). The latter subspecies which is thought to be restricted to montane coniferous forests in southeastern New Mexico and Arizona, and northern Mexico, is taxonomically marginal (Wattel 1973). The original research separating the Apache Goshawk as a subspecies is based on a small sample size (Wattel 1973). However, preliminary data from an on-going study of Accipiter taxonomy indicate the Northern Goshawk at the southern edge of its range is larger than other Northern Goshawk populations (Wayne Worley, BYU, personal communication, March, 1985).

Morphological characteristics of the Northern Goshawks trapped in the Jemez Mountains were compared with morphological data of museum specimens of nesting Northern Goshawks collected in southern New Mexico and Arizona, and Mexico (Table 1). The museum specimen data was kindly provided by Wayne Worley of the Zoology Department at Brigham Young University. The comparison was conducted to determine whether or not the Jemez Mountain Northern Goshawks were northern representatives of the Apache Goshawk or southern representatives of A.g. atricapillus.

TABLE 1

A MORPHOLOGICAL COMPARISON BETWEEN THE JEMEZ MOUNTAINS, N.M., NORTHERN GOSHAWKS AND THE APACHE GOSHAWKS

Measurement	Jemez Mountains		Apache Goshawks ^a			
	Ad. Male	Ad. Female	Juv. Male	Juv. Female	Ad. Male	Ad. Female
Tail Length (mm)						
\bar{X}	235 (1) ^b	263 (3)	246.5 (2)	280.5 (2)	233.5 (6)	265.9 (7)
Range ($\pm 1SD$)	235	251.5 - 274.5	240.1 - 252.9	255.7 - 295.3	227.2 - 239.8	260.3 - 271.5
Wing Chord (mm)						
\bar{X}	333 (1)	363 (3)	341 (2)	368 (2)	328 (8)	369.4 (7)
Range	333	358.4 - 367.6	340.3 - 341.7	353.9 - 382.1	321 - 335	360.6 - 378.2
Hallux Length (mm)						
\bar{X}	22 (1)	31.7 (3)	26.9 (2)	31.3 (2)	27.9 (9)	33.1 (7)
Range	22	30.6 - 32.8	25.3 - 28.5	30.9 - 31.7	27 - 28.8	30.8 - 35.4
Culmen Length (mm)						
\bar{X}	--- ^c	---	20.6 (2)	24.2 (2)	21.4 (9)	24.7 (6)
Range	---	---	19.3 - 21.9	23.1 - 25.3	20.5 - 22.3	23.9 - 25.5
Weight (g) ^d						
\bar{X}	724 (1)	968 (3)	794.3 (1)	---	781.1 (1)	1,139 (2)
Range	724	836 - 1,100	794.3	---	781.1	1,023 - 1,255
Tarsal Width (mm)						
\bar{X}	11 (1)	73.4 (1)	---	---	---	---
Range	11	73.4	---	---	---	---
Tarsal Length (mm)						
\bar{X}	12.4	81.9 (3)	---	---	---	---
Range	12.4	79.6 - 84.2	---	---	---	---

a. The Apache Goshawk data are from measurements of museum specimens obtained by Wayne Worley of the Zoology Department at Brigham Young University. This includes specimens from southern New Mexico, southern Arizona, and Mexico. These data cannot be published in other documents without the consent of Wayne Worley.

b. Numbers in parantheses are sample sizes.

c. These data are not available.

d. Few body weights on the museum specimens were obtained at time of collection.

The mean tail length and wing chord of the one adult male from the Jemez Mountains is within the range of these parameters for the adult male Apache Goshawks. However, hallux length and body weight of the Jemez Mountain male are smaller than the range of these parameters for the adult male Apache Goshawks. The mean tail length, wing chord, and hallux length of the Jemez Mountains females are within the range of these measurements for the Apache Goshawk females. However, the average weight of the Jemez Mountain females is smaller than the weights of the two female Apache Goshawk specimens for which weight data are available. Data on culmen length were not available for the Jemez Mountain birds and tarsal width and tarsal length data were not available for the museum specimens so comparisons of these parameters were not made.

These preliminary data suggest the Jemez Mountain Northern Goshawks are not significantly smaller than the Apache Goshawks. However, sample sizes are too small for a definitive comparison. This data set will be expanded as more nesting adults are trapped during the duration of the project. In addition, a comparison of the Jemez Mountain Northern Goshawks to the morphometric data on A.g. atricapillus is also necessary.

Cooper's Hawk

The Cooper's Hawk is monotypic. Friedman (1950) and other taxonomists originally considered the eastern (A. c. copperii) and western (A. c. mexicanus) populations to be sub-specifically distinct; however, this designation has since been dismissed (Jones 1979; Millsap 1981).

The morphometric data on the six Cooper's Hawks trapped in the Jemez Mountains were compared with the morphometric data from southwestern museum specimens collected by Wayne Worley (Table 2).

There was no significant difference ($P=0.15$) in the tail length, wing chord, hallux length, and culmen length of the Jemez Mountain hawks and the museum specimens. Weight, tarsal width, and tarsal length data were not available for the museum specimens so comparisons of these characteristics could not be made. The results of Wayne Worley's comparison of the southwestern museum specimens with northern specimens is not available (Wayne Worley, personal communication, March, 1975).

TABLE 2

A MORPHOLOGICAL COMPARISON BETWEEN THE JEMEZ MOUNTAINS, N.M. COOPER'S HAWKS
AND OTHER SOUTHWESTERN COOPER'S HAWKS^a

Measurement	Jemez Mountains		New Mexico, Arizona, and Mexico ^a			
	Ad. Male	Ad. Female	Juv. Male	Juv. Female	Ad. Male	Ad. Female
Tail Length (mm)						
\bar{X}	186 (3) ^b	208 (3)	189 (7)	213.9 (17)	183.7 (15)	208.8 (12)
Range ($\bar{X} \pm 1$ SD)	178.5 - 193.5	202.4 - 213.6	179.6 - 198.4	206.4 - 221.4	178.7 - 188.7	203.5 - 214.1
Wing Chord (mm)						
\bar{X}	232 (3)	261 (3)	226.8 (8)	257.2 (17)	233.9 (16)	262.5 (13)
Range	226.7 - 237.3	256 - 266	221.8 - 231.8	247.3 - 267.1	228.9 - 238.9	256.6 - 268.4
Hallux Length (mm)						
\bar{X}	19.3 (3)	24.5 (3)	18.8 (9)	22.8 (18)	19.1 (16)	23.7 (13)
Range	18.9 - 19.7	23.9 - 25.1	18.1 - 19.5	22 - 23.6	18.3 - 19.9	22.6 - 24.8
Culmen Length (mm)						
\bar{X}	14.8 (3)	18.7 (3)	15.2 (8)	17.7 (18)	15.4 (16)	18.5 (13)
Range	12.6 - 17.0	18.4 - 19.0	14.7 - 15.7	16.9 - 18.5	14.7 - 16.1	17.8 - 19.2
Weight (g)						
\bar{X}	272 (3)	493 (3)	--- ^c	---	---	---
Range	257 - 287	450 - 536	---	---	---	---
Tarsal Width (mm)						
\bar{X}	7.6 (3)	10.7 (3)	---	---	---	---
Range	7.3 - 7.9	8.0 - 13.4	---	---	---	---
Tarsal Length (mm)						
\bar{X}	63.1 (3)	72.1 (3)	---	---	---	---
Range	61 - 65.2	71.4 - 72.8	---	---	---	---

a. These data are from measurements of museum specimens obtained by Wayne Worley of the Zoology Department at Brigham Young University. These data cannot be published in other documents without the consent of Wayne Worley.

b. Numbers in parantheses are sample sizes.

c. These data are not available.

However, based on previous research (Snyder and Wiley, 1976) we assume the southwestern Cooper's Hawks to not be significantly different morphologically from other populations of Cooper's Hawks.

GENERAL DISTRIBUTION AND STATUS

Northern Goshawk

The Northern Goshawk is an uncommon nesting species in the study area. Six active Northern Goshawk nests were located during 1984. The elevation range of the nest locations was narrow, 7,640 - 8,250 ft. However, home ranges (see Home Range Results) extended from 7,000 - 10,000 ft. This species probably does not nest below 7,000 ft in the study area. Of 20 nests located in Colorado, none were below 7,000 ft (Shuster 1980). The lower elevation limit of this species probably corresponds with the lower limit of the montane forests.

The recorded upper elevation of nests probably reflects sampling bias rather than an accurate picture of their true upper elevation limit. Stands at elevations above 9,000 ft received less search effort than stands below 9,000 ft. Based on radio-tracking data, Northern Goshawks are known to range up to 10,000 ft. The upper limit probably corresponds to the availability of nest sites.

The Northern Goshawk was observed in all of the major montane and subalpine forest associations that occur on the study area. Most of the observations were in mature old growth stands of Ponderosa Pine (Pinus ponderosa), mixed conifer (Ponderosa Pine, Douglas fir (Pseudotsuga menzeisii), White Fir (Abies concolor)), and aspen (Populus tremuloides). They occupied stands ranging from those with closed, mature canopies with few shade-tolerant understory trees to stands with more open, mature canopies and more understory trees.

The minimum distance between two active nests was 3.5 km. The average home range size of the four radio-tagged Northern Goshawks was 13.4 km². Due to the small sample size of nests and observations of individuals, density estimates and mean spacing distances between pairs were not calculated. However, we predict that the nesting density of Northern Goshawks in the Jemez Mountains is a function of the availability of montane forests with mature, large trees for nests.

Cooper's Hawk

The Cooper's Hawk is common nesting species in the study area. Nine nesting pairs were located at elevations ranging from 5,550 - 7,980 ft. Home ranges of five radio-tagged individuals ranged from 6,000 - 8,400 ft. The lower elevation recorded for a nest reflects the lower limit of the study area. Cooper's Hawks may nest above 8,000 ft in the study area but their upper limit probably corresponds with the upper edge of the ecotone separating mid-elevation forests of mixed conifers from subalpine spruce/fir forests.

Cooper's Hawks were observed in a wider variety of habitats than the Northern Goshawk. They were observed in all major forest and woodland communities in the study area, except for subalpine forests. The majority of observations were in riparian habitats, and second-growth montane forests of Ponderosa Pine and mixed conifer.

The minimum distance between two active nests was 7 km. The average home range for five radio-tagged Cooper's Hawks was 9 km. Based on these observations and numerous sightings of unmarked birds we think that pairs of Cooper Hawks can be expected at 2 - 5 km intervals throughout the study area. We predict there is a minimum of one pair in or near every major drainage in the Upper Sonoran and montane communities within the study area. These predictions will be tested as more nest sites are located during the remainder of the study.

HOME RANGE CHARACTERISTICS

During 1984, ten Accipiters were radio-tracked from June 6 - August 28 (Table 3). A total of 566 Accipiter locations were obtained during the 210 hr spent tracking the hawks. The radio transmitters on birds 9 and 10 (not a mated pair) failed prematurely so few locations were obtained for these birds. Home ranges were only calculated for those birds observed for a minimum of 10 hrs.

To develop a reliable and representative estimate of the home range size for each Accipiter, ranges were calculated using locations with maximum measurement accuracies ranging from 62.5 m to 1 km. This means that the home range estimates with a maximum measurement uncertainty of 1 km include all locations with a measurement accuracy of ≤ 1 km and range estimates with a maximum measurement uncertainty of

TABLE 3

CODE NAMES, DURATION OF TRACKING PERIOD, AND HOME RANGE SIZE OF RADIO-TAGGED
NORTHERN GOSHAWKS AND COOPER'S HAWKS IN THE JEMEZ MOUNTAINS, N.M.

<u>Code Name</u>	<u>Tracking Period</u>	<u>No. of Hours in a Tracking Period^a</u>	<u>Number of Locations</u>	<u>Home Range^b Area (km²)</u>
<u>Northern Goshawks</u>				
1 Male	June 13 - August 28, 1984	40	76	28.2 (11.0)
2 Female	June 6 - August 11, 1984	27	63	5.9 (18.0)
3 Female	June 8 - August 3, 1984	31	60	11.4 (5.9)
7 Female	July 13 - August 18, 1984	22	76	8.1 (17.0)
Mean for all Goshawks				13.4
Mean for Females				8.5
<u>Cooper's Hawks</u>				
4 Female	July 1 - August 13, 1984	19	58	9.1 (14.0)
5 Female	July 2 - August 3, 1984	15	66	2.9 (26.0)
6 Male	July 12 - August 26, 1984	22	82	3.9 (25.0)
8 Male	July 5 - August 24, 1984	19	63	32.0 (20.0)
9 Female ^c	July 15 - July 24, 1984	10	22	0.8 (26.0)
10 Male ^c	July 1 - July 4, 1984	5	0	--
Mean for all Cooper's Hawks				9.7
Mean for Males				18.0
Mean for Females				4.3

a. With the exception of Bird #10, this does not include time spent in the radio-tracking periods during which the birds could not be located.

b. This is a minimum convex polygon estimate with a measurement accuracy of 1 Km. The percent error of the home range size based on this location accuracy is in parantheses.

c. The radio transmitter on this bird failed prematurely so few locations were obtained for this individual.

62.5 m include all locations with a measurement accuracy of ≤ 62.5 m. The results of this error analysis of home range size for each bird are presented in Figures 1-9.

As noted in Figures 1-9, as the maximum measurement uncertainty decreases, home range size decreases. This is a result of a decrease in the number of locations used to calculate home range size as the required measurement accuracy increases. It has been documented in many radio-telemetry studies that home range size is partially a function of the number of locations. (Forsman et al. 1984; Harmata 1984). The home range size increases with increasing number of locations until it reaches an asymptote where additional locations are not required. The level of this asymptote varies between species and between individuals within a population. Forsman et al. (1984) found, on the average, 131 days were required to determine 80% of the total home range used by individual Spotted Owls. The relatively long period required to determine the total (or near total) home range reflected the fact that, due to their sedentary nature, owls visited some portions of their home ranges infrequently.

The active foraging behavior of Accipiters probably allows for accurate estimates of their home range with fewer data points than required by the more sedentary Spotted Owls. In addition, unlike the Spotted Owl the Accipiters cannot be radio-tracked for longer than approximately 2-3 months (60-90 days) a year due to battery life restrictions on their smaller transmitters, the potential for molting the transmitter along with their tail feathers at the end of the nesting season, and, at least in the case of the Cooper's Hawk, their emmigration from the study area in the fall. So, although an adequate number of locations were collected for Birds 1-8 to estimate a home range size, these home ranges must be estimated based on as many locations as possible.

The optimum home range estimate would be based on maximum accuracy of locations (e.g., sighting of individuals; zero uncertainty) and optimum number of locations. However, due to the equipment limitations and scale of the topographic maps, and the rapid continual movement of the birds, an accuracy of less than 250 m is probably unattainable. However, at a maximum accuracy of 250 m, on the average, 25% of the locations are eliminated resulting in home ranges that may be smaller than the true home ranges.

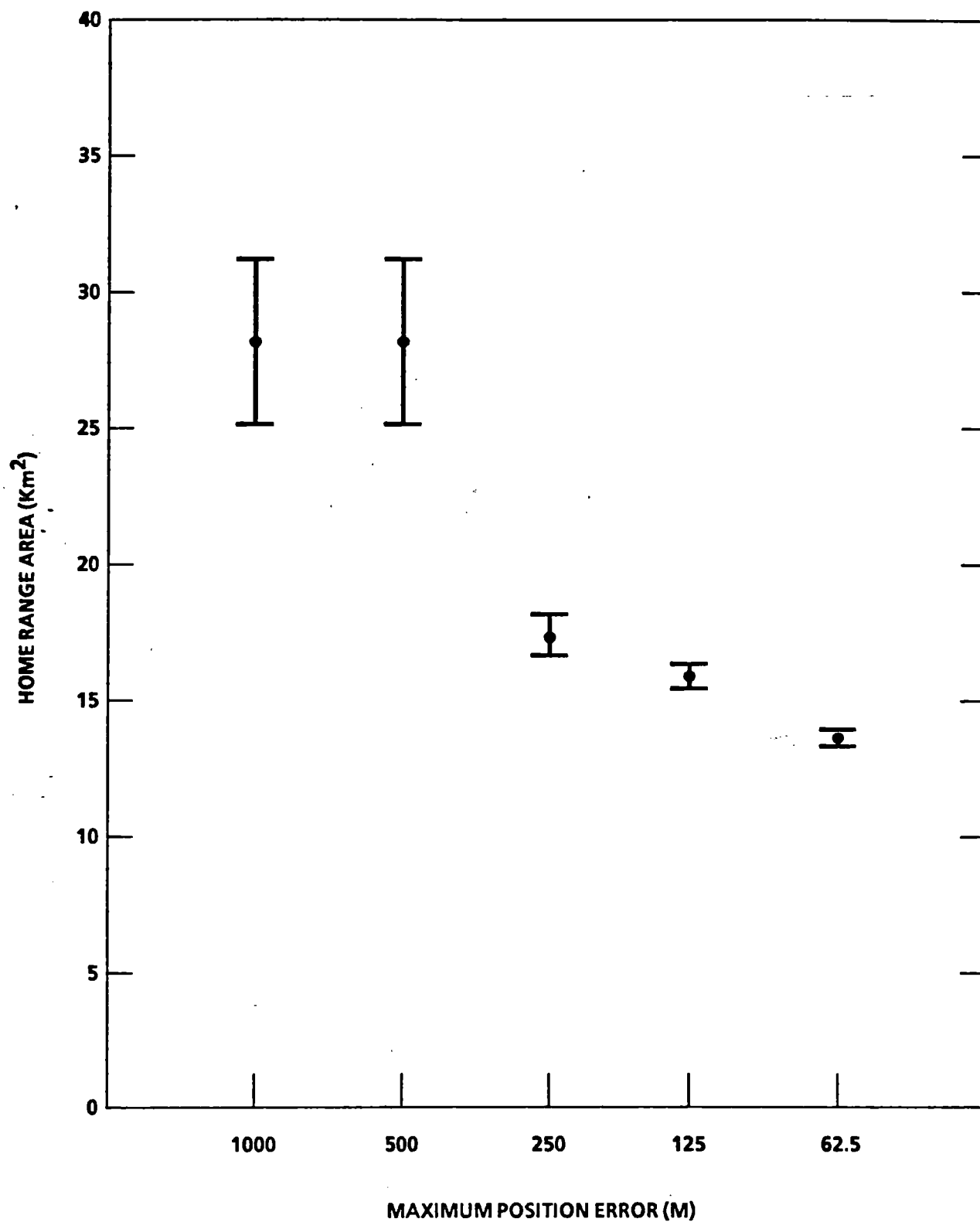


Figure 1. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 1. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

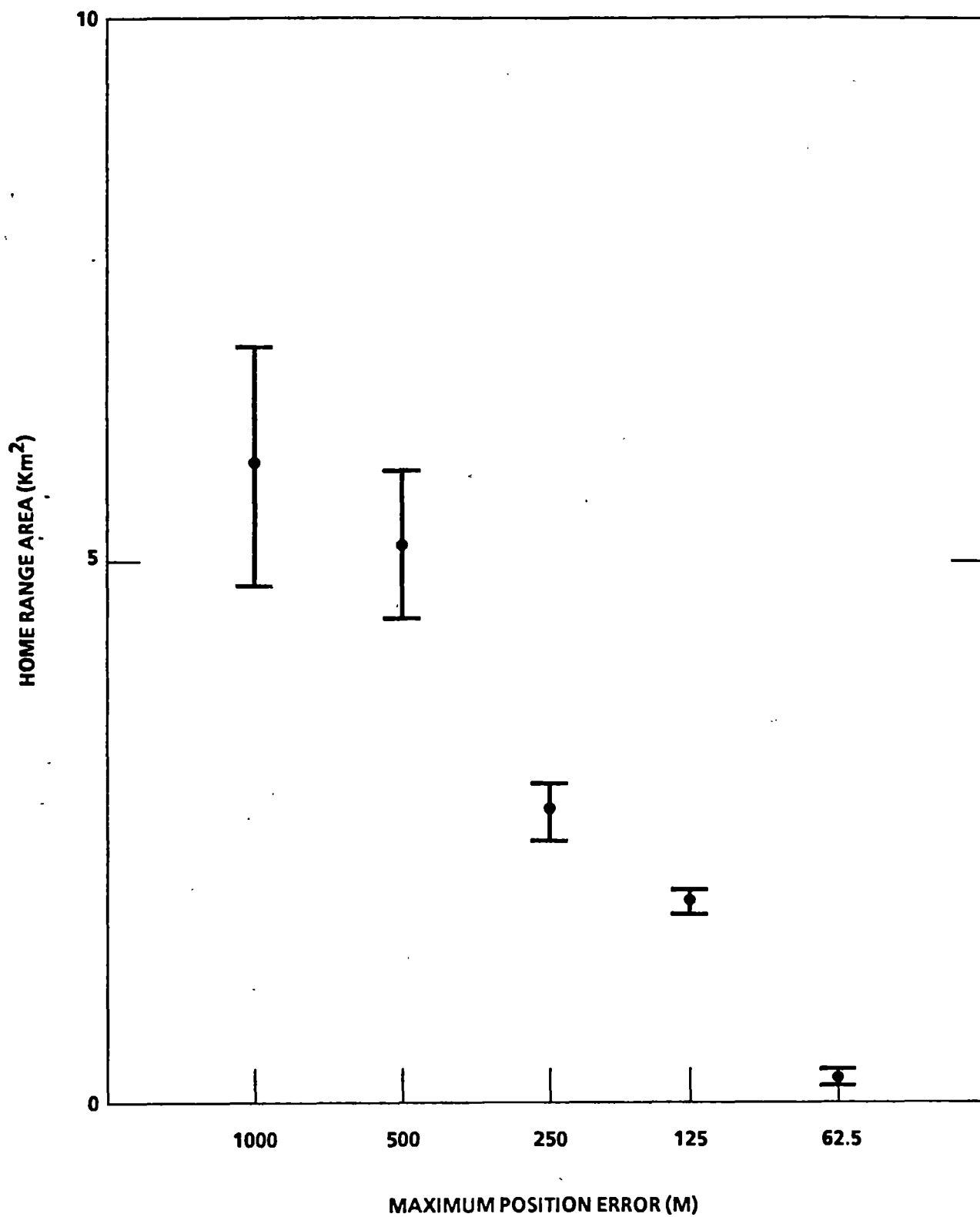


Figure 2. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 2. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

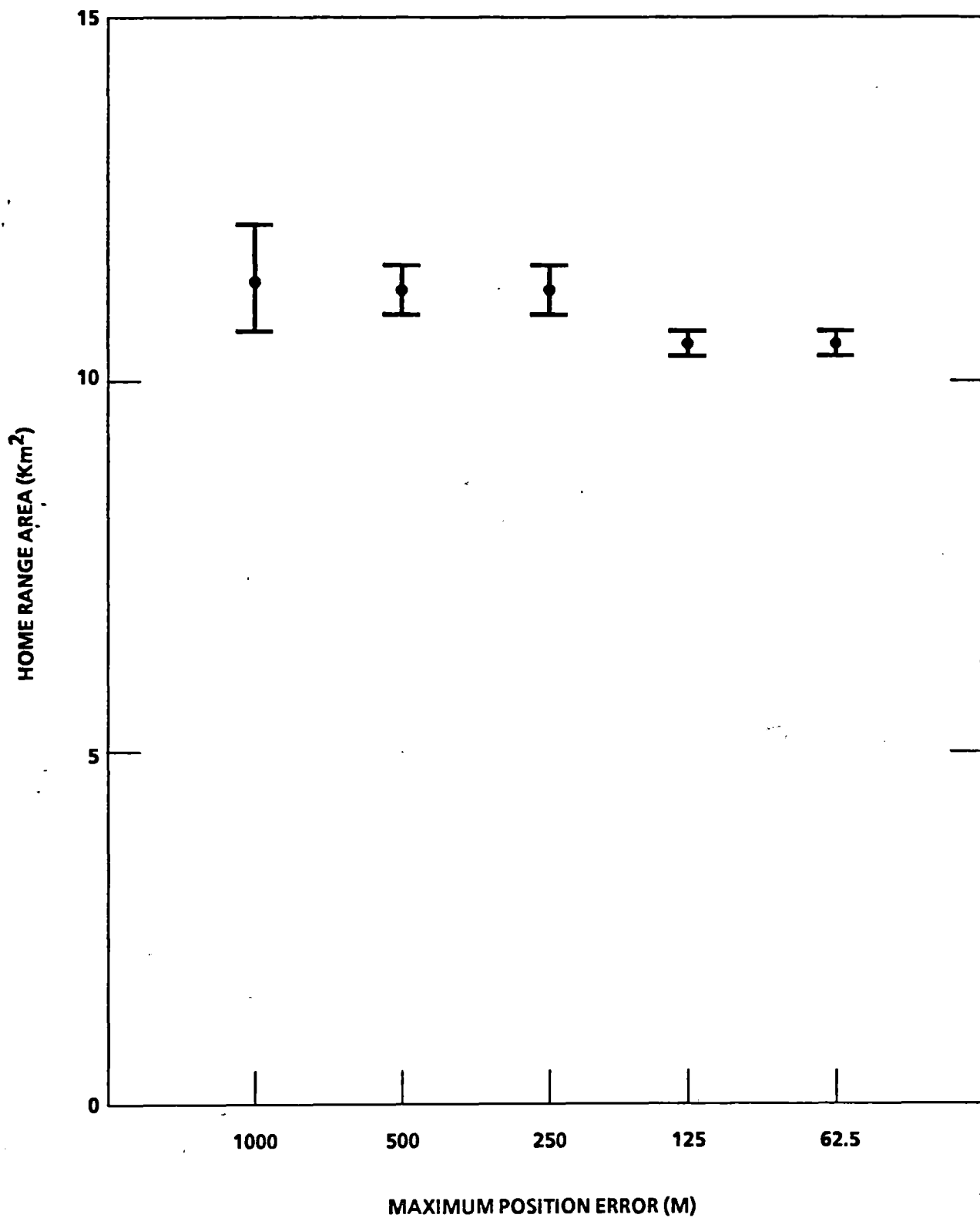


Figure 3. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 3. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

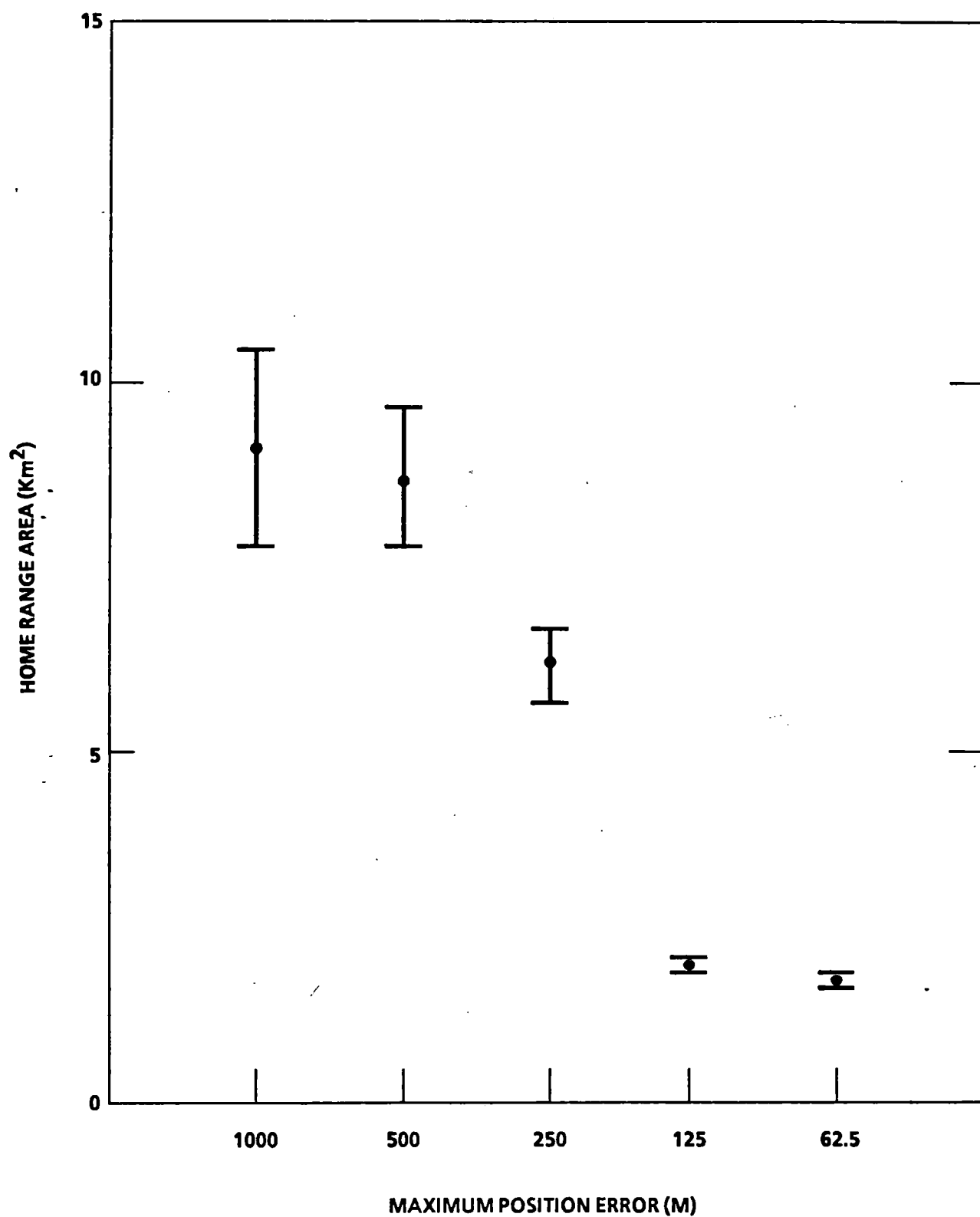


Figure 4. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 4. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

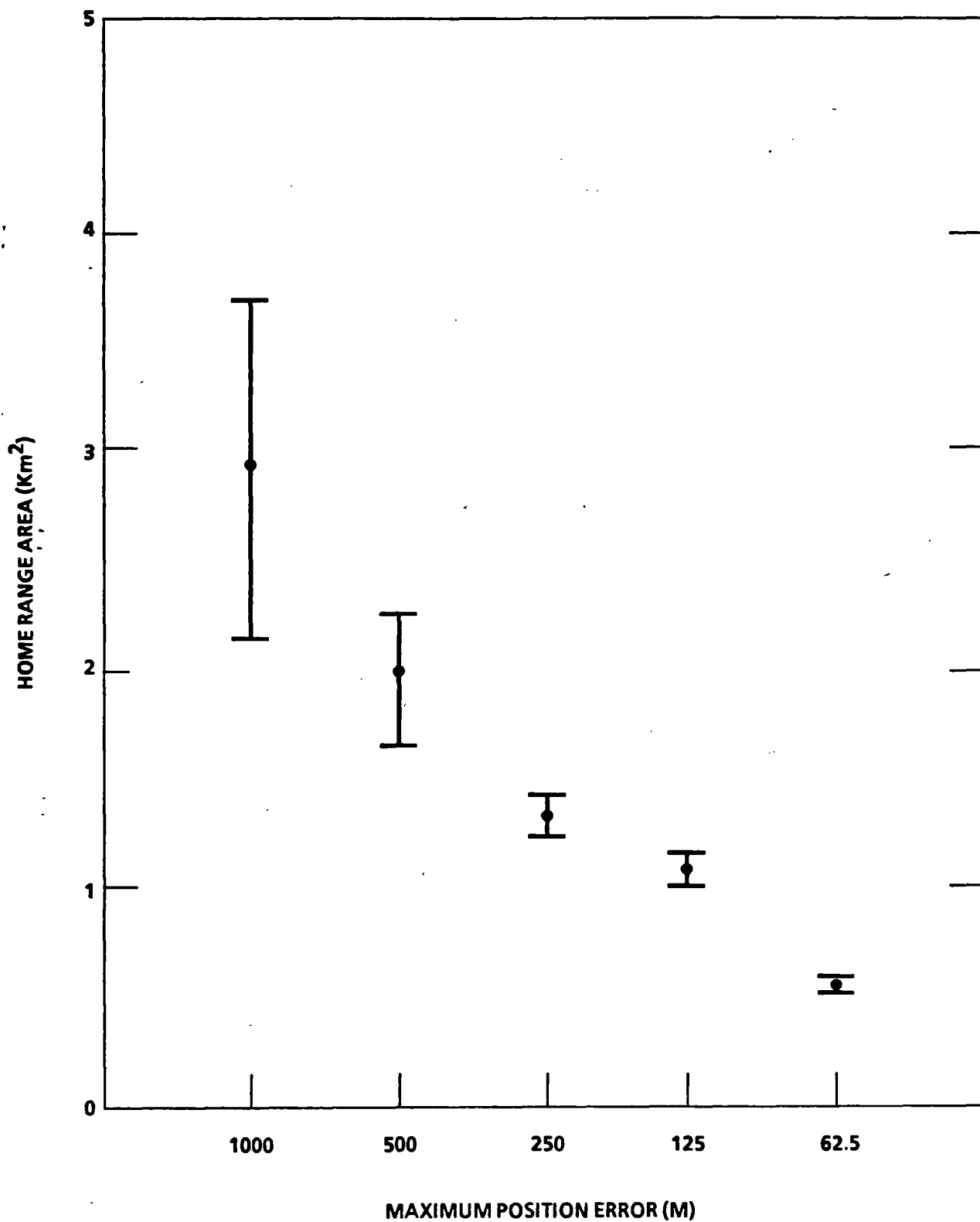


Figure 5. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 5. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

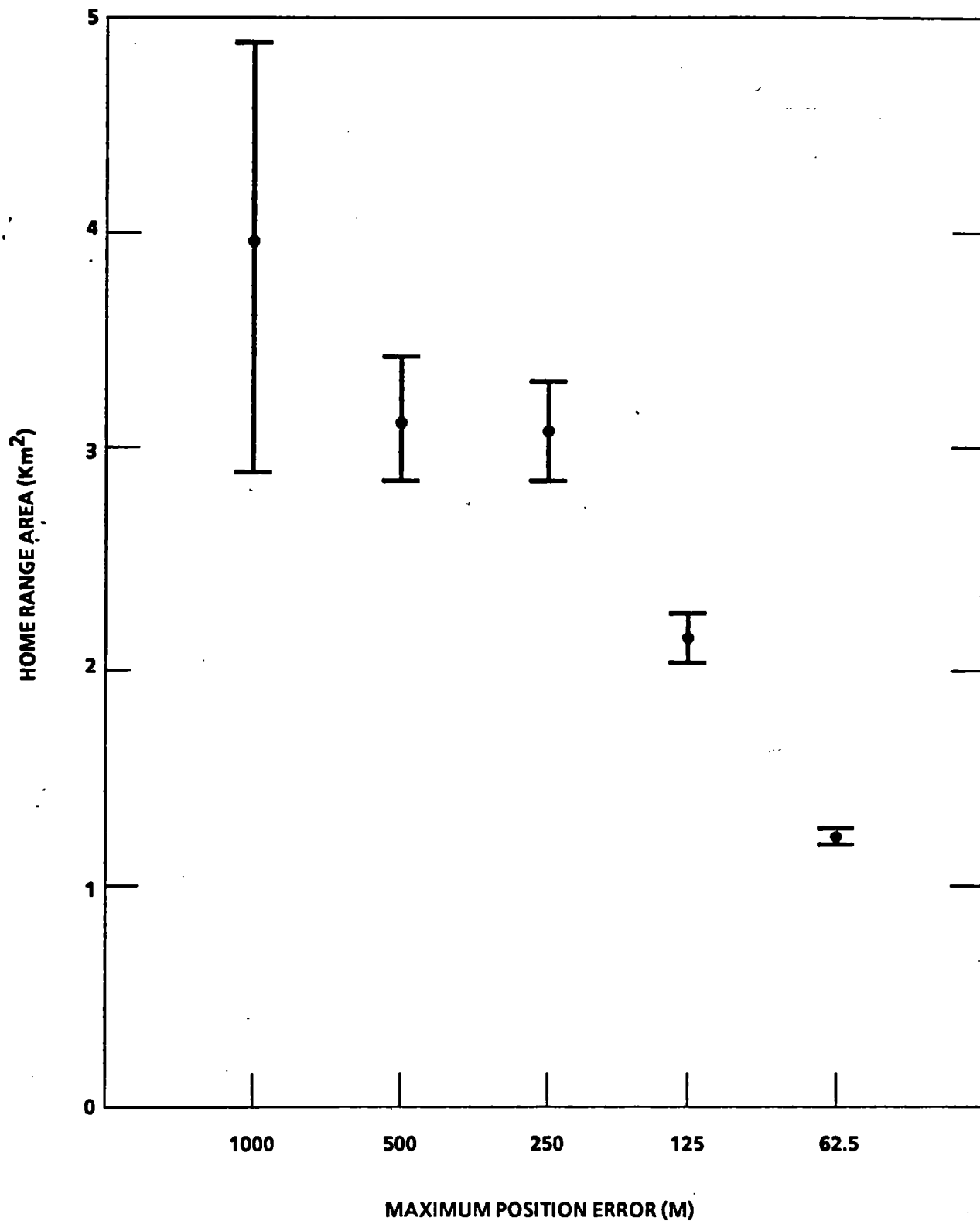


Figure 6. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 6. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

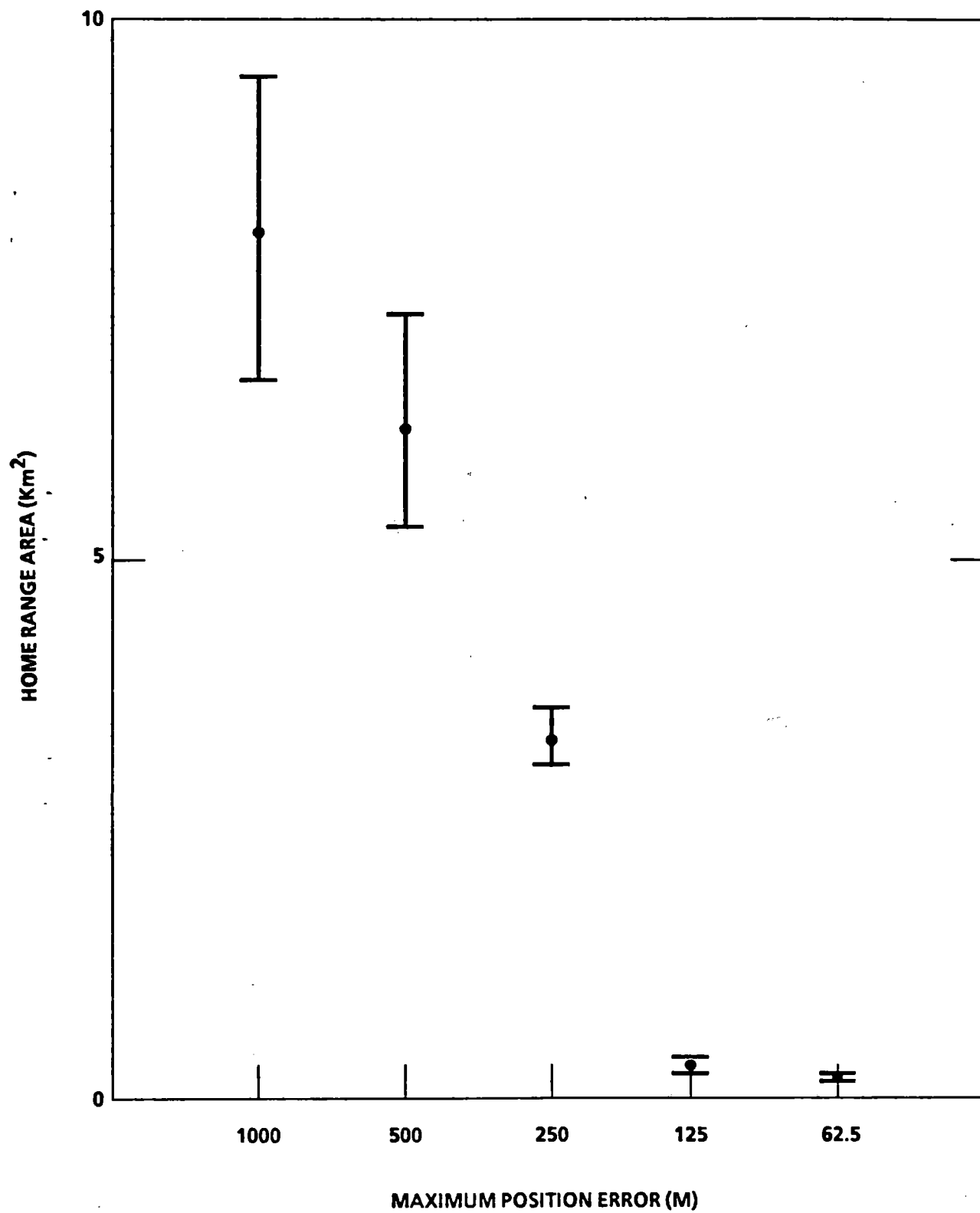


Figure 7. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 7. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

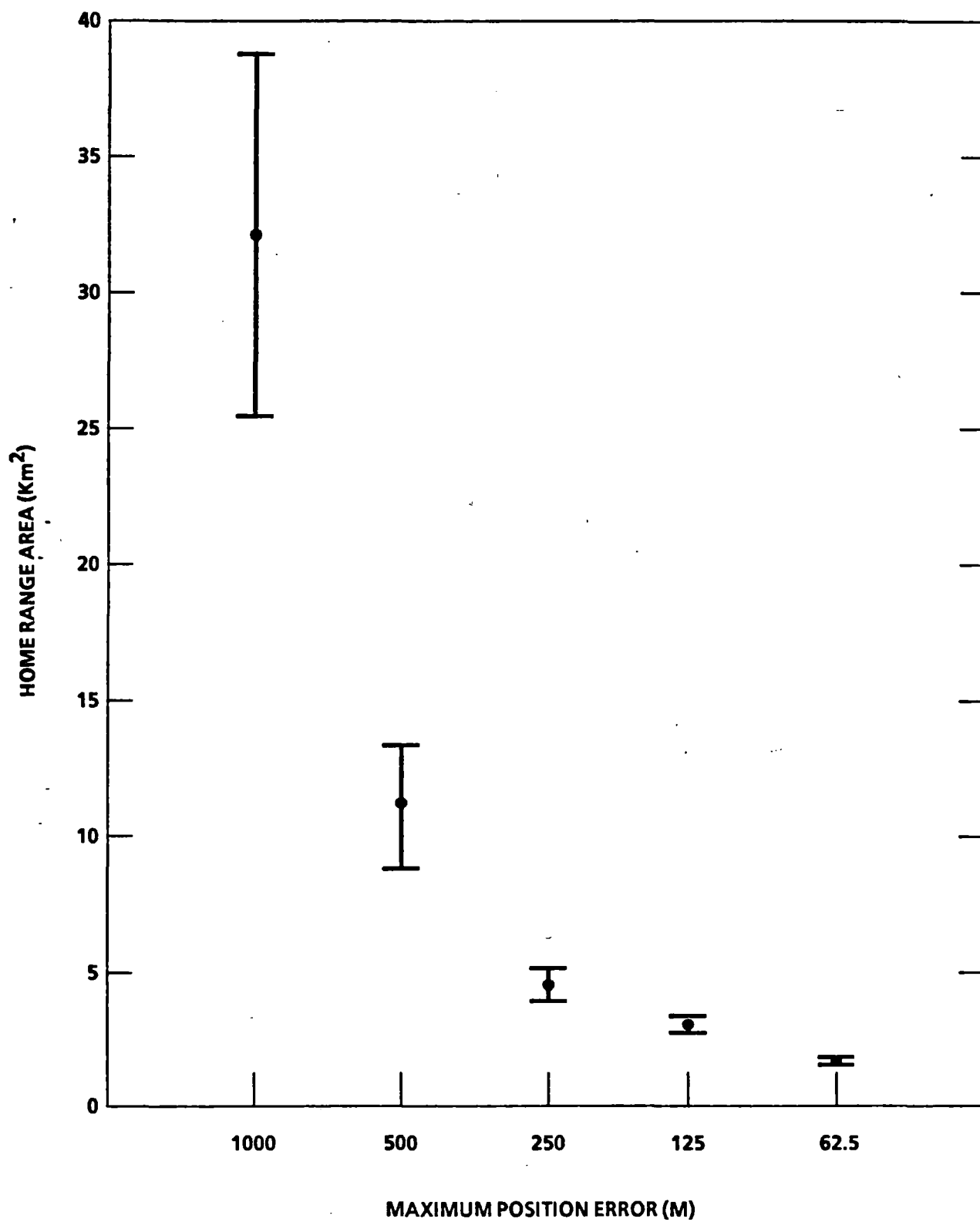


Figure 8. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 8. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

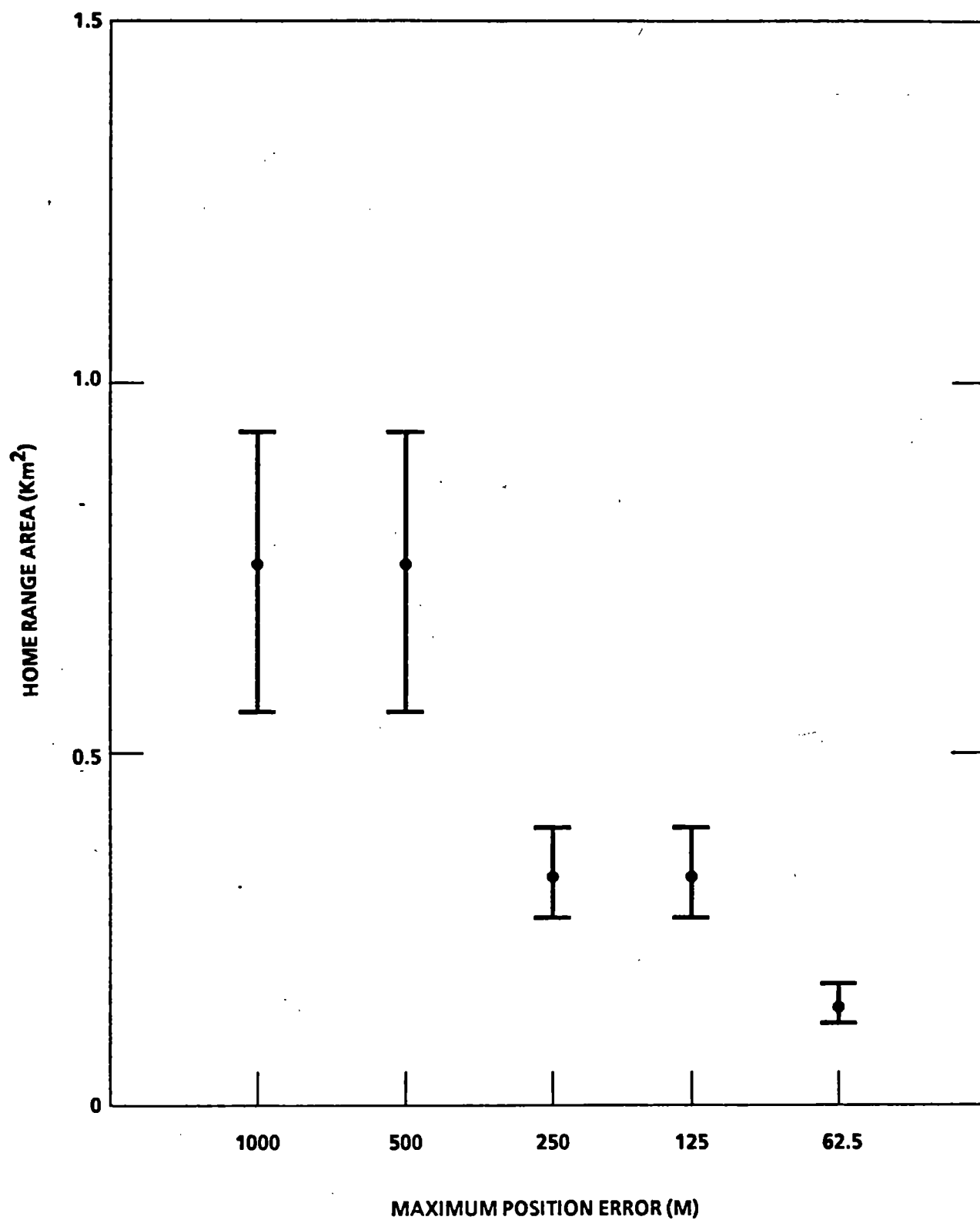


Figure 9. The effect of varying the measurement uncertainty of radio locations on home range estimates for Bird 9. Vertical lines indicate the measurement uncertainty of the home range calculated at each maximum position error.

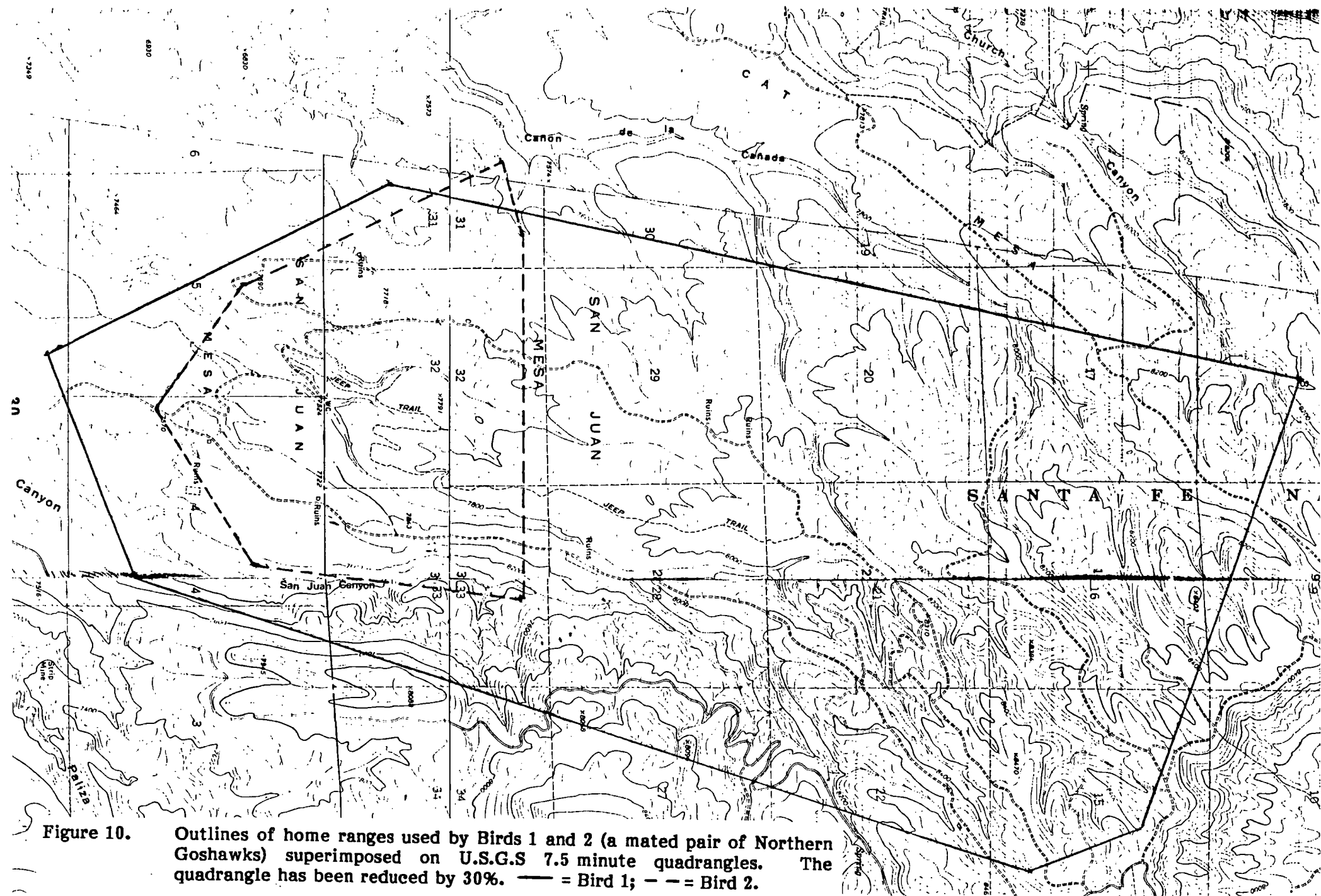
For all birds except Bird 8, the home range sizes calculated with 500 m and 1,000 m maximum fix error are not significantly different ($P < 0.05$). Therefore, because the home ranges with locations with a maximum fix error of 1,000 m incorporate more locations in most cases than home ranges calculated with locations with a maximum fix error of 500 m, it is used as the estimate of *Accipiter* home range size in the following sections. As more locations are collected during subsequent field seasons, locations with maximum fix errors of 250-500 m will be used to calculate home range sizes.

Home range size averaged 13.4 km^2 for Northern Goshawks and 9.7 km^2 for Cooper's Hawks (Table 3). However the largest home range size was recorded for a male Cooper's Hawk (Bird 8). Female home range sizes were significantly smaller than male home range sizes ($P < 0.05$) (Table 3). We hypothesize this is a result of the female's role in nest defense which requires more frequent visits to the nest.

The estimated home range boundaries for Bird 1-9 were copied onto 7.5 minute U.S.G.S. quadrangles. The home range boundaries for Birds 1 and 2, a mated pair of Northern Goshawks, are presented in Figure 10. Figure 11 is the home range boundaries of Bird 3, a female Northern goshawk, and Birds 5 and 6, a mated pair of Cooper's Hawks. Figure 12 presents the home range boundaries for Bird 7, a female Northern Goshawk. Figure 13 presents the home range boundaries for Bird 4, a female Cooper's Hawk, and Birds 8 and 9, a mated pair of Cooper's Hawks. Because this a public access document the nest locations are not indicated on the maps to protect the birds. Although the nest was in the home range of each bird, it was not the center of the home range for most of the birds.

Many of the home range boundaries appear to be influenced by topographic features. For example, the eastern and western boundaries of the home ranges for Birds 1 and 2 correspond with two major perennial drainages: San Juan Canyon and Canon de la Canada. The northeastern boundary of Bird 3's home range is Los Alamos Canyon. Other examples can also be noted on the maps. It is possible, however, the boundaries may be due to patterns of prey distribution rather than physical barriers.

The home range boundaries do not appear to be established by intraspecific or interspecific territorial spacing. As noted in Figure 11, the home range of Bird 3 (a female Northern Goshawk) overlapped with the home ranges of Birds 5 and 6 (a mated pair of Cooper's Hawks). In addition, the home range of Bird 4 (a female Cooper's Hawk)



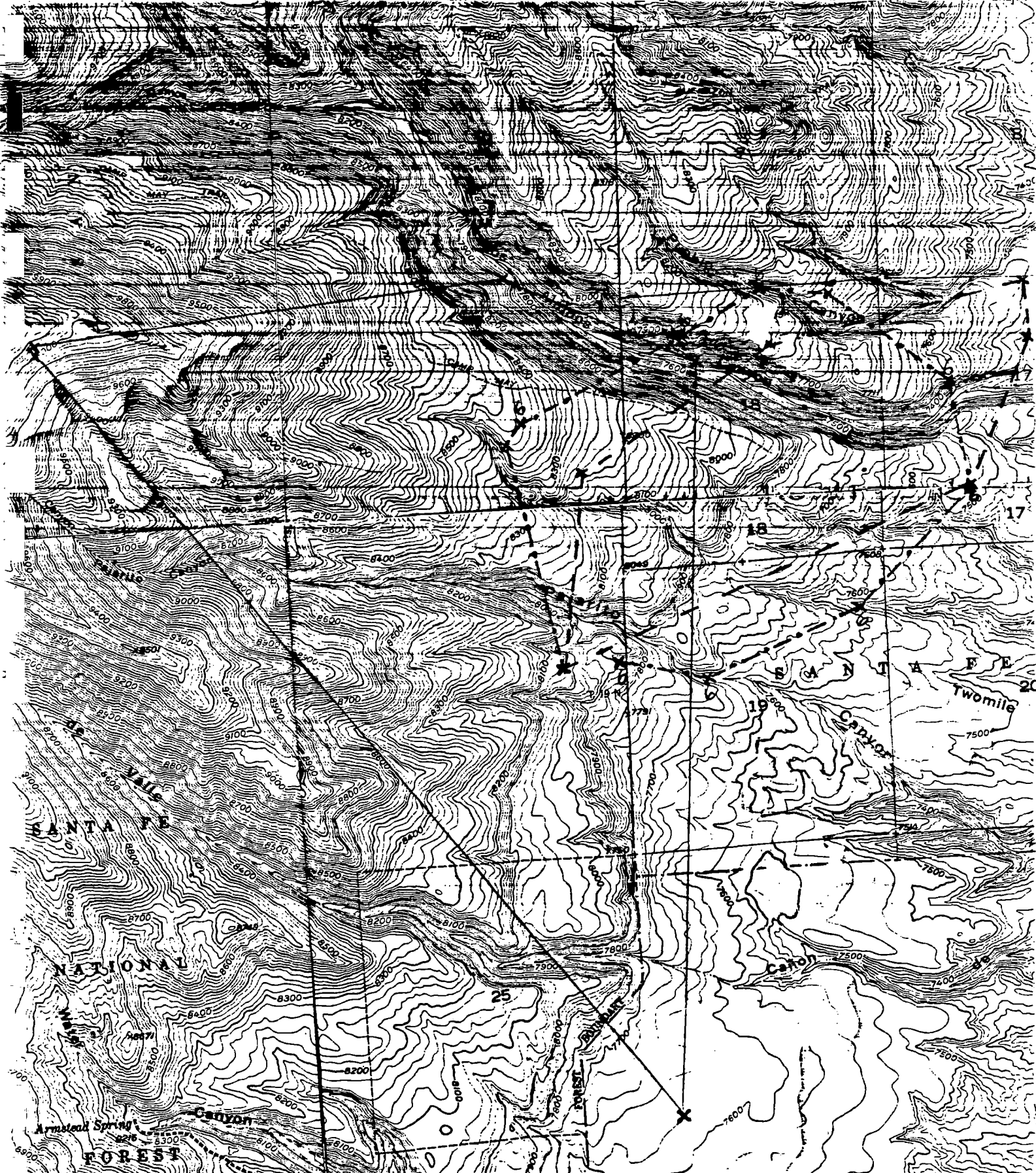


Figure 11. Outlines of home ranges used by Birds 3 (a female Northern Goshawk), 5 and 6 (a mated pair of Cooper's Hawks) superimposed on U.S.G.S 7.5 minute quadrangles. The quadrangle was reduced by 30%.
 — = Bird 3; - - = Bird 5; - · - = Bird 6.

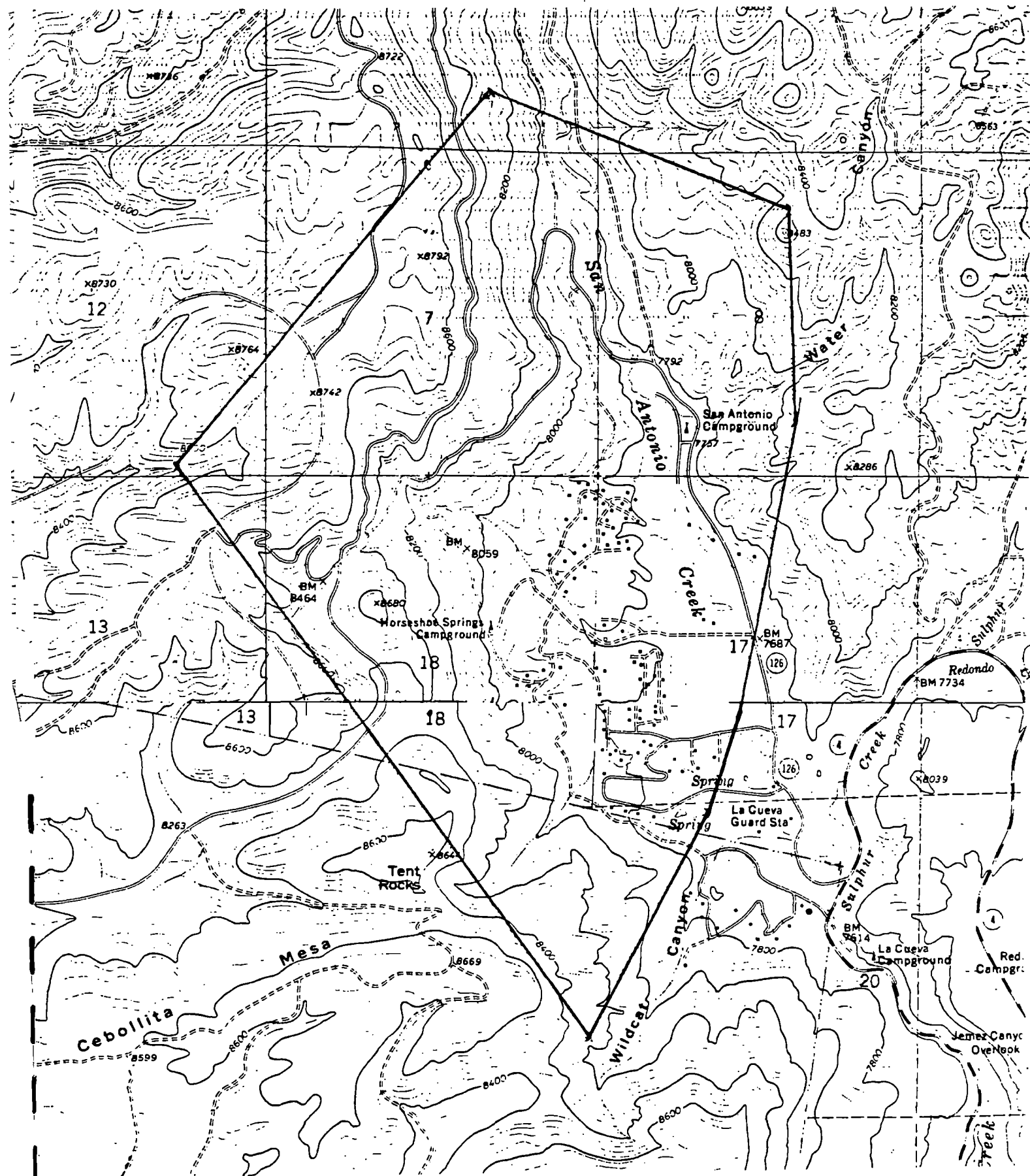


Figure 12. Outline of home range used by Bird 7 (a female Northern Goshawk) superimposed on U.S.G.S 7.5 minute quadrangles.



Figure 13. Outlines of home ranges used by Birds 4 (a female Cooper's Hawk), 8 and 9 (a mated pair of Cooper's Hawks) superimposed on U.S.G.S 7.5 minute quadrangles. The quadrangle was reduced by 25%. — — = Bird 4; - · - · = Bird 8; — = Bird 9.

Figure 13 goes here.

overlapped extensively with Bird 8 (an adjacent male Cooper's Hawk) home range. However, Bird 4's home range did not overlap with Bird 9's (the adjacent female Cooper's Hawk) home range. It is not known if this is actually a situation of non-overlap or a function of the small number of locations collected for Bird 9 due to permature radio-failure. If more data could have been collected on Bird 9, it is possible overlap between the two females may have been documented. Bird 8's home range also overlapped with the home ranges of Birds 5 and 6. Home range overlap between the Northern Goshawk pairs was not documented because adjacent nests were probably not located.

The extensive overlap between pairs of Cooper's Hawks suggest that for this species, density estimates based on home range boundaries or mean spacing distances may significantly underestimate their actual population density.

Home ranges occupied by paired individuals also overlapped extensively. More data are needed to determine whether or not the paired individuals used the same foraging locations at the same time, e.g., seasonal changes in home range use to reduce hunting interference.

Average estimates of home range sizes in this study area are considerably smaller than the home range estimates reported for the same species in Oregon, but considerably larger than the ranges for the same species in Michigan and Wyoming (Reynolds 1983). Mean home range size for Cooper's Hawks in Wyoming and Michigan, and Oregon are 1.7 km^2 and 15.9 km^2 , respectively. Mean home range size for Northern Goshawks in Wyoming and Michigan, and Oregon are 2.12 km^2 and 24.63 km^2 , respectively (Reynolds 1983).

These differences not only reflect the different techniques used to estimate home range size (none of these estimates in the other studies are based on radio-telemetry) but also may reflect an actual geographic variation in range size. These range sizes are probably influenced by the distribution of suitable vegetation communities with suitable prey populations.

The relationship of human disturbance, particularly timber harvest, to the home range size of the Jemez Mountain Accipiters is not well defined. This is a result of the small sample size of radio-tagged birds of each species, and the range of variation of

human disturbance activities between individual home ranges. For example, the hypothesis that hawks nesting in an area with a lot of human disturbance will have a larger home range than birds nesting in less disturbed areas is not supported by this data set. Bird 3 had the largest home range of the three female Northern Goshawks and she was located in the least disturbed site. There was no recent logging activity in this entire home range, unlike within the home ranges of Birds 2 and 7, and the only major disturbance in Bird 3's home range was hiking for recreation and limited Los Alamos National Laboratory activity.

Of the female Cooper's Hawks, Bird 5's home range received the heaviest human use because it was centered around the Los Alamos Ski Hill Road and Los Alamos Canyon, both high density recreation areas. The home ranges of the other two females (Birds 4 and 9) were predominantly on DOE and U.S. Park Service Lands with no vehicular traffic and limited public access. However, the home range of Bird 4 was the largest home range of the three females. The reverse trend was noted between the Cooper's Hawk males (Birds 6 and 8). Bird 6 was the mate of Bird 5 (the heavily disturbed area) and his home range was considerably larger than the range of Bird 8, which was predominantly located on limited public access federal lands.

For human disturbance to cause an increase in home range size it probably has to have a significant impact on prey populations. Prey population data for this study area are needed to accurately examine the effects of human disturbance on Accipiter home range size.

Although, the variation in home range size documented in this study does not demonstrate a clear relationship with human disturbance, some inferences can be made from examinations of the birds' movement patterns within their estimated home ranges.

Computerized time-series plots of the movement patterns of the radio-tagged Accipiters are presented in Figures 14 through 22. The home range boundaries are also indicated on these plots.

These plots indicate that large sections of land within the defined home ranges are not utilized by the Accipiters. Although the reasons for these avoidance patterns are not known, they may be related to human disturbance. For example, the northern and southeastern portions of the home ranges of Birds 1 and 2 were rarely occupied

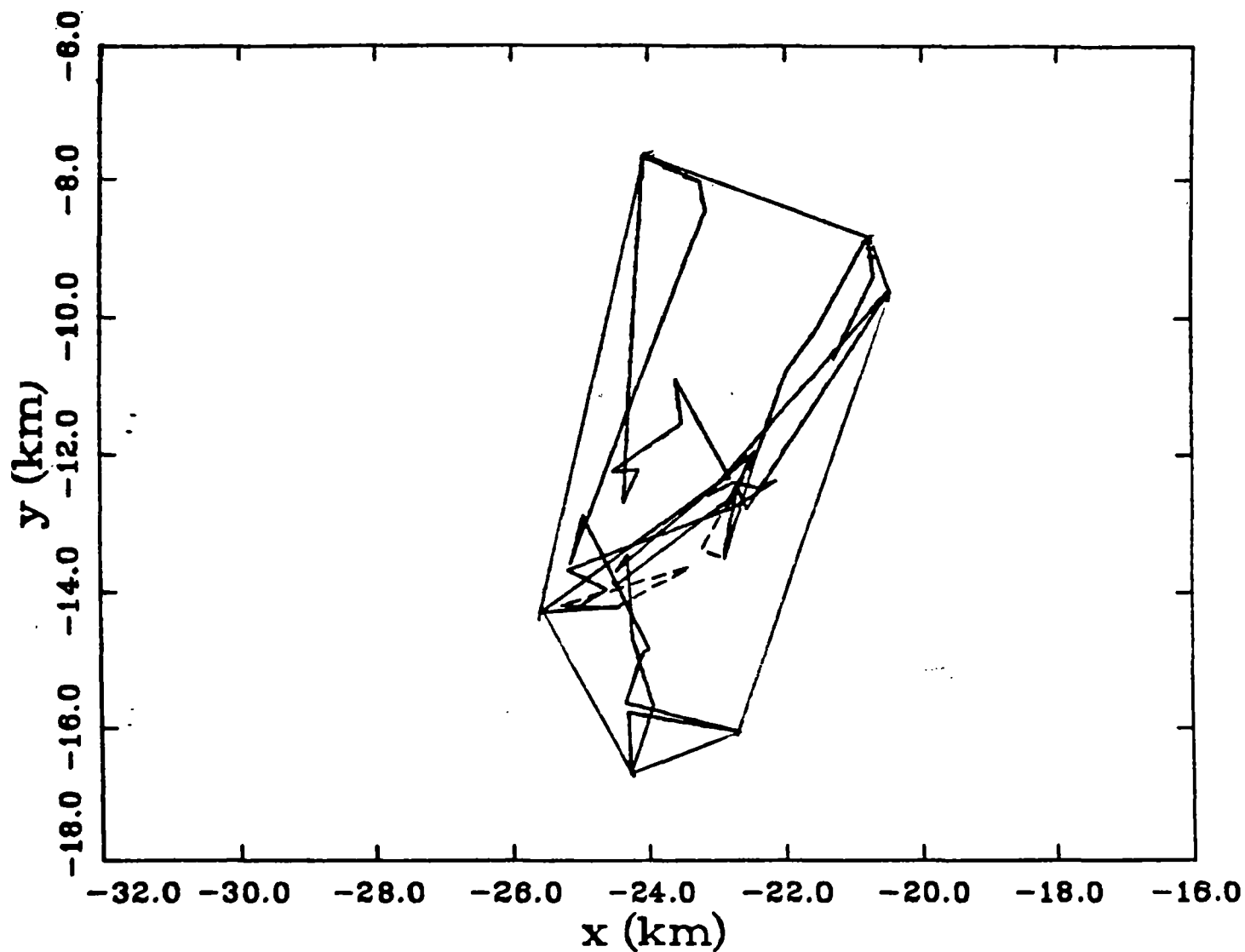


Figure 14. Computer generated map illustrating movement patterns of Bird 1 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km. The outermost solid line is the home range boundary.

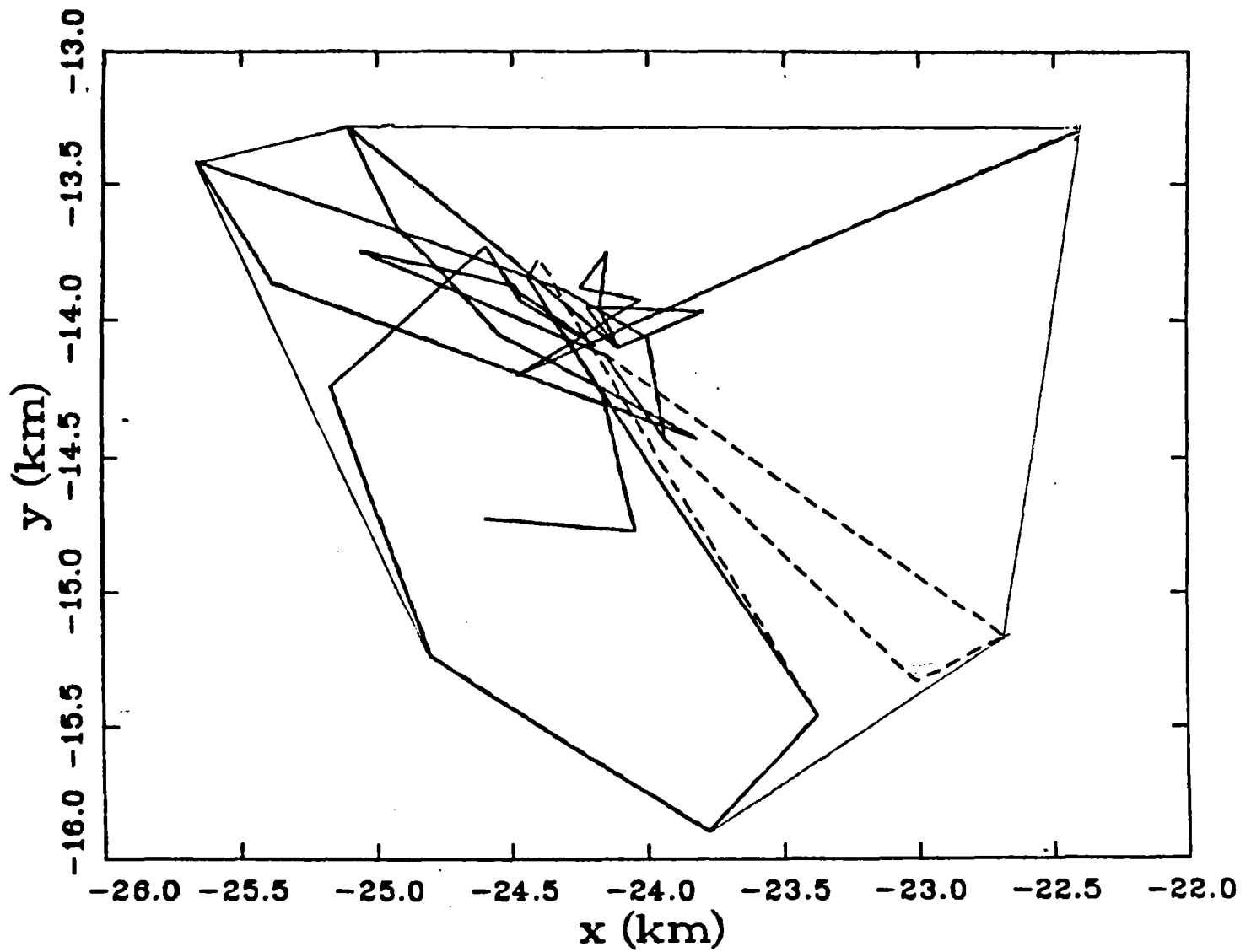


Figure 15. Computer generated map illustrating movement patterns of Bird 2 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

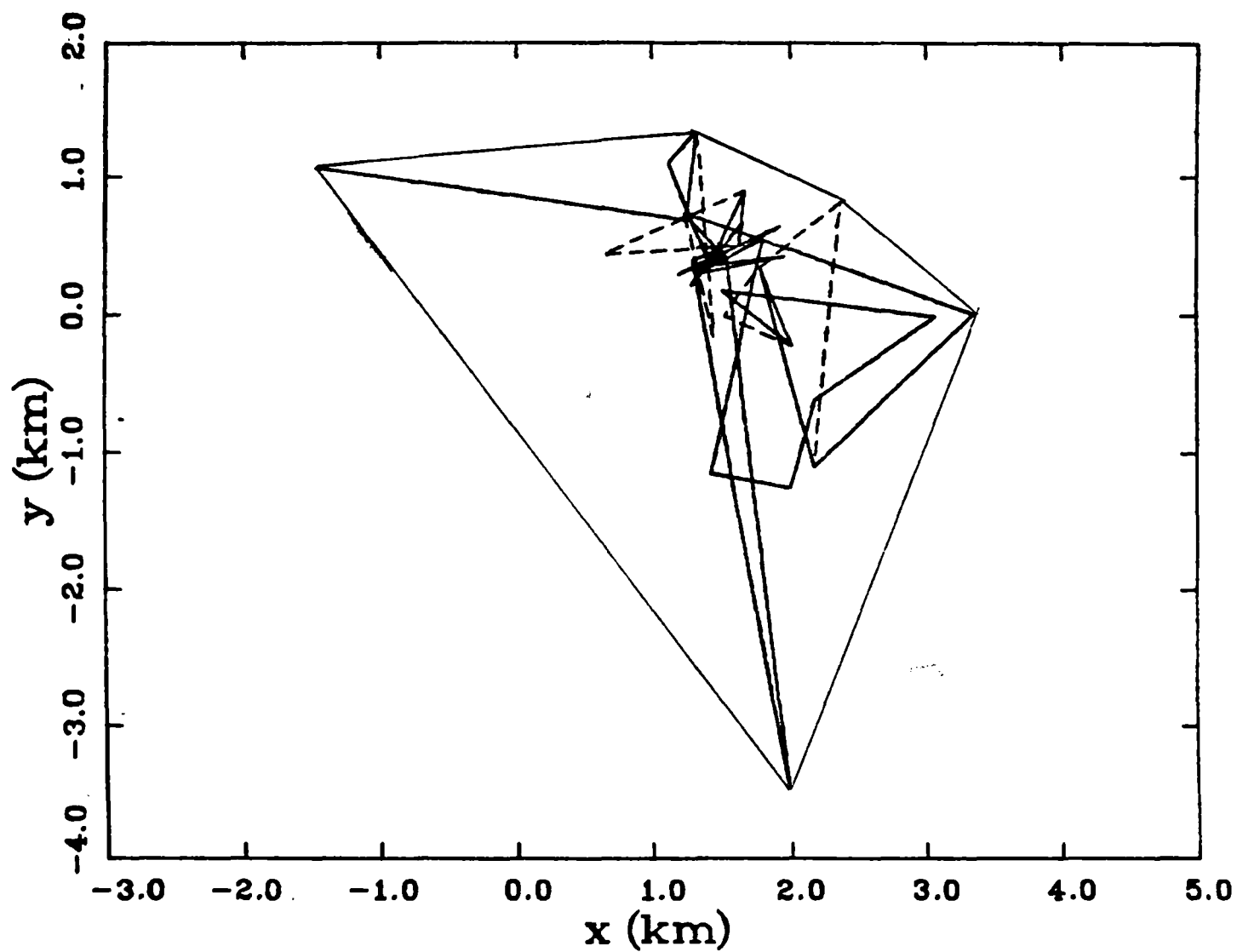


Figure 16. Computer generated map illustrating movement patterns of Bird 3 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

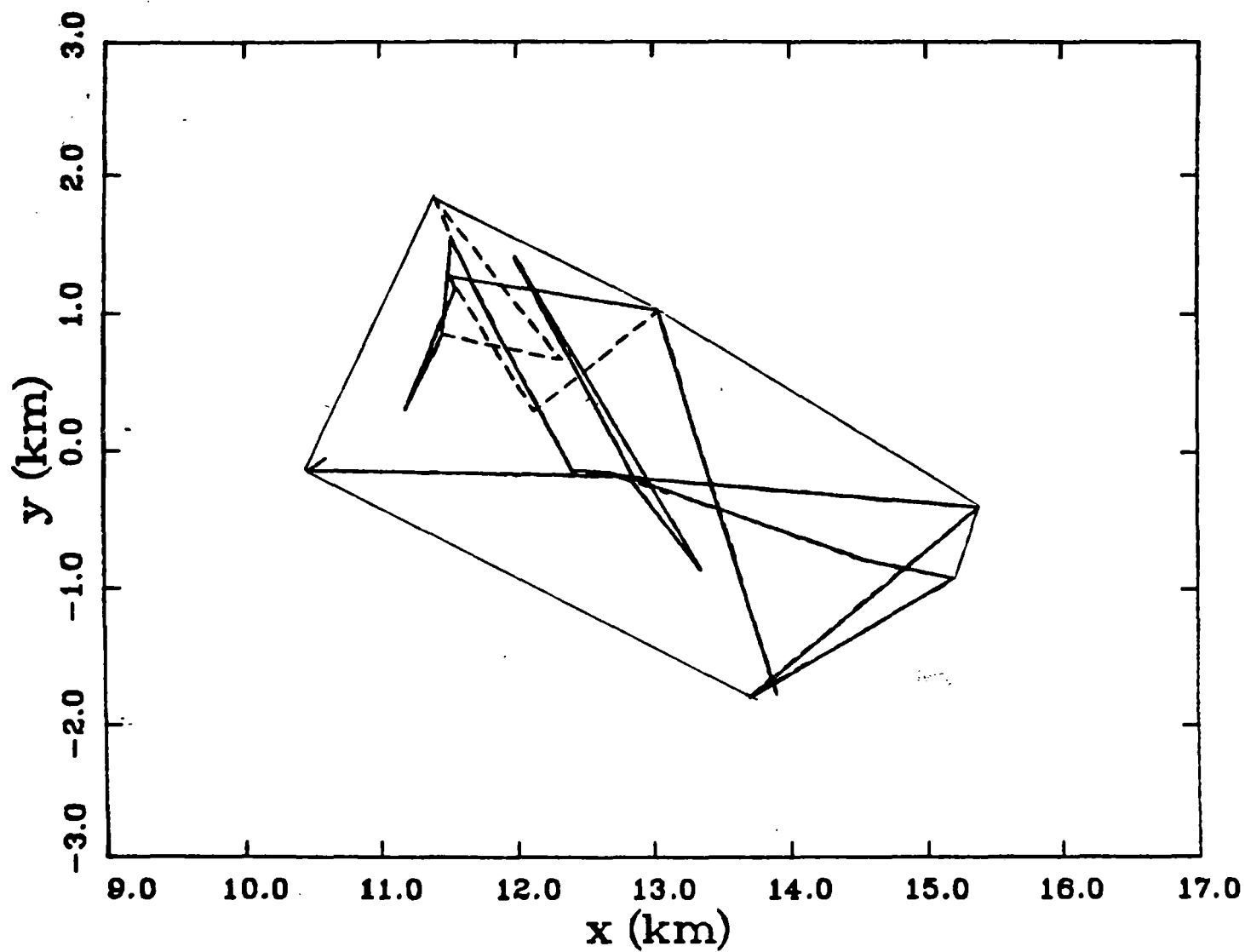


Figure 17. Computer generated map illustrating movement patterns of Bird 4 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

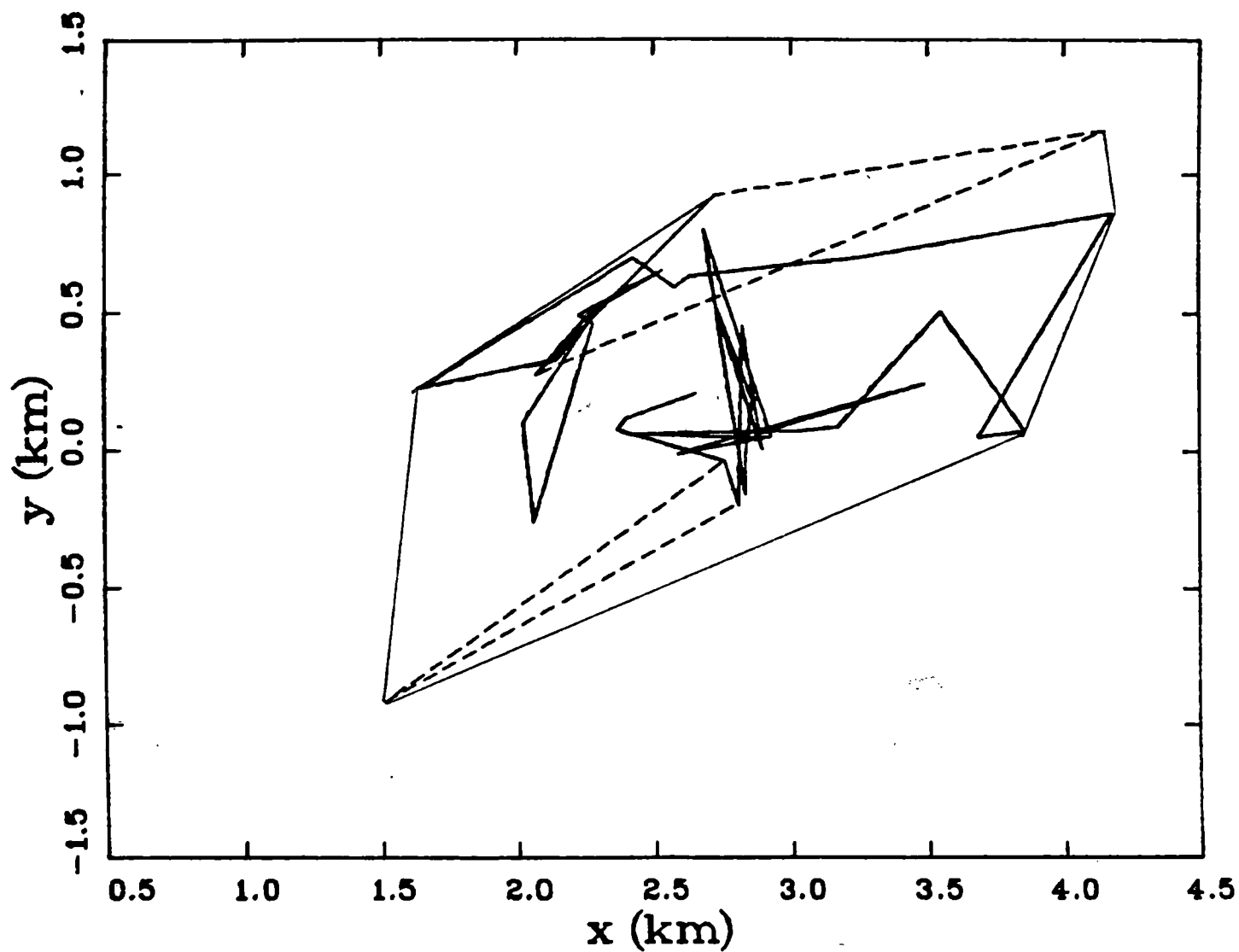


Figure 18. Computer generated map illustrating movement patterns of Bird 5 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

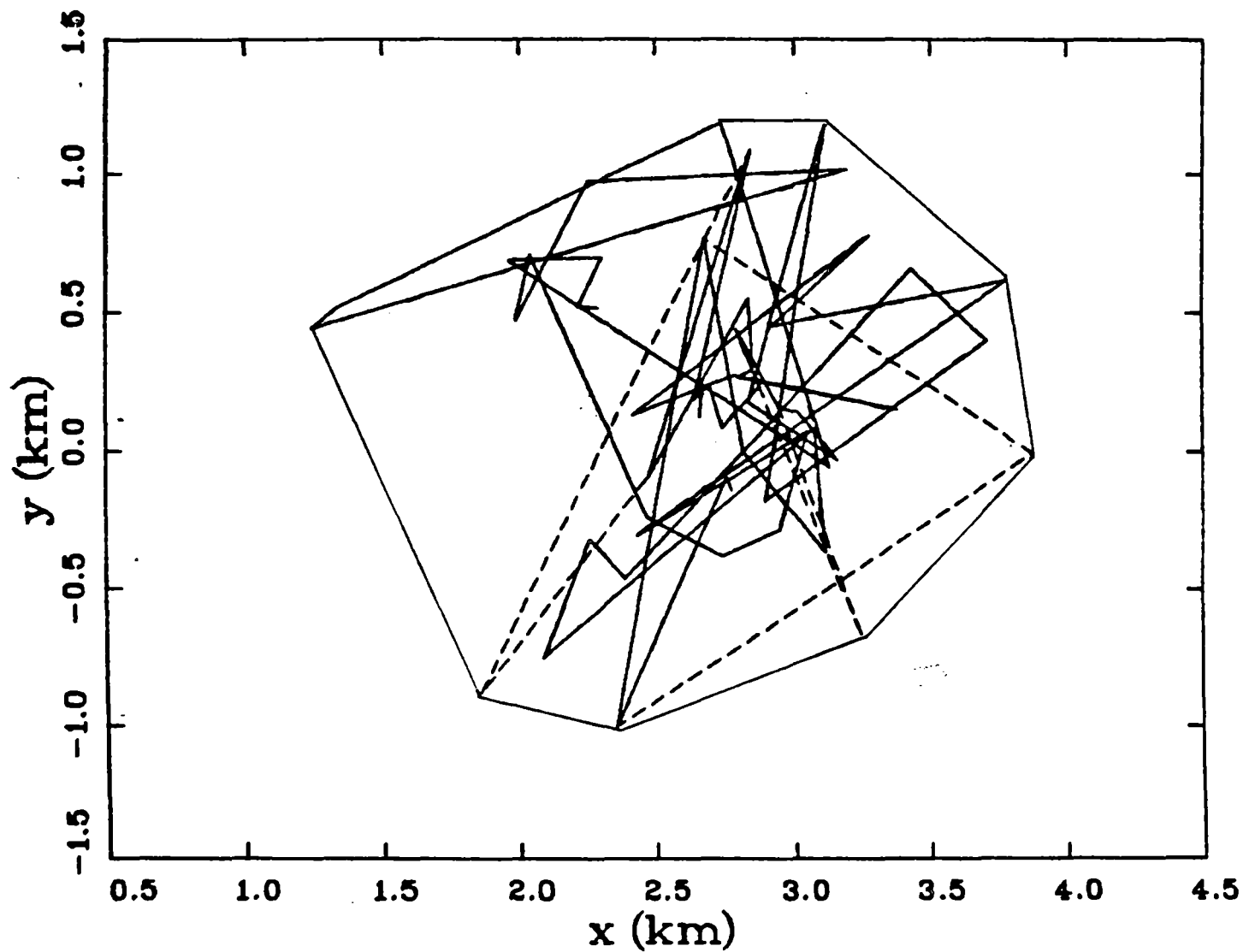


Figure 19. Computer generated map illustrating movement patterns of Bird 6 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

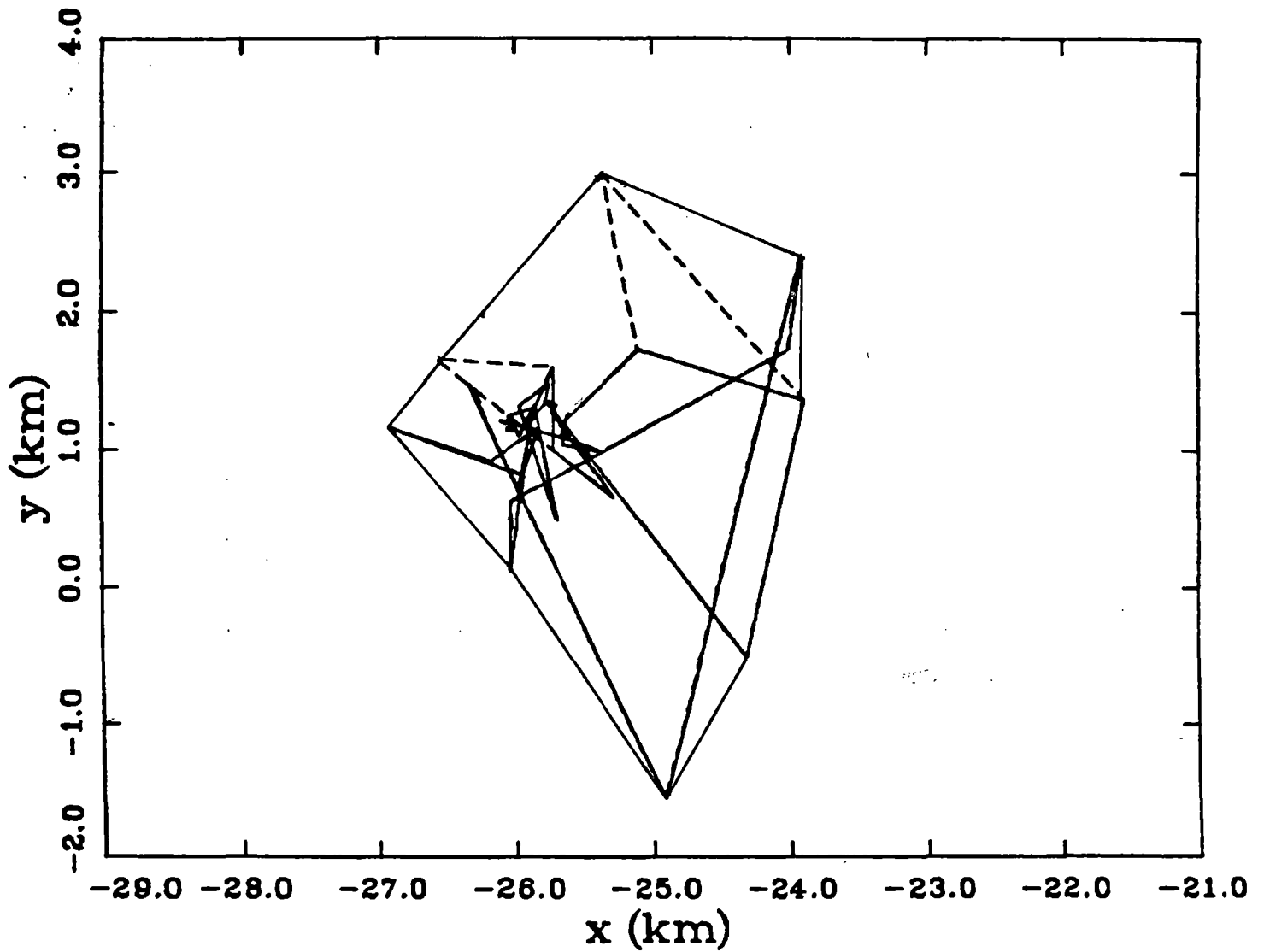


Figure 20. Computer generated map illustrating movement patterns of Bird 7 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

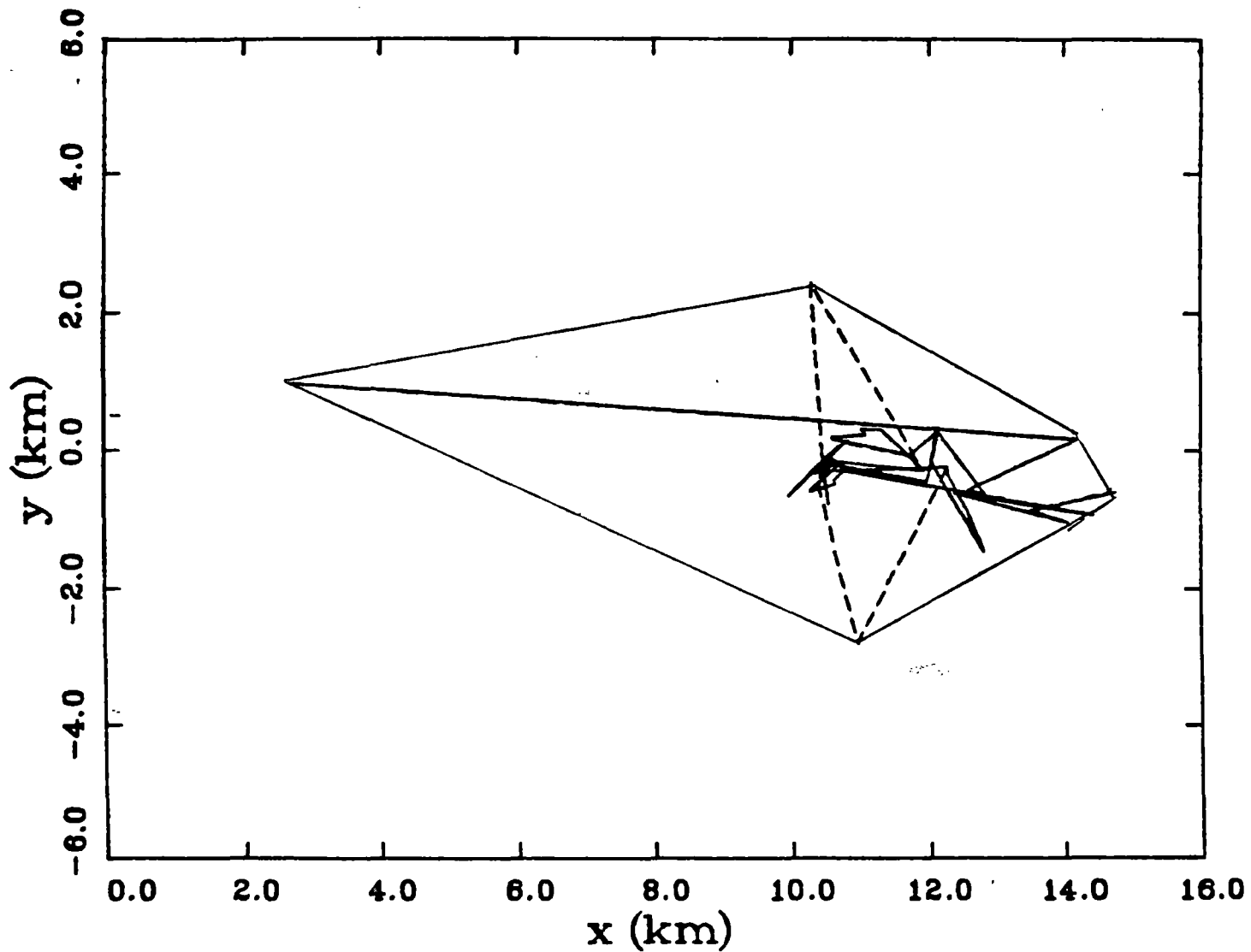


Figure 21. Computer generated map illustrating movement patterns of Bird 8 within its estimated home range. The solid lines include all radio fixes with an accuracy of 500 m. The dashed line represents movement patterns based on fixes with an accuracy between 501 m and 1 km.

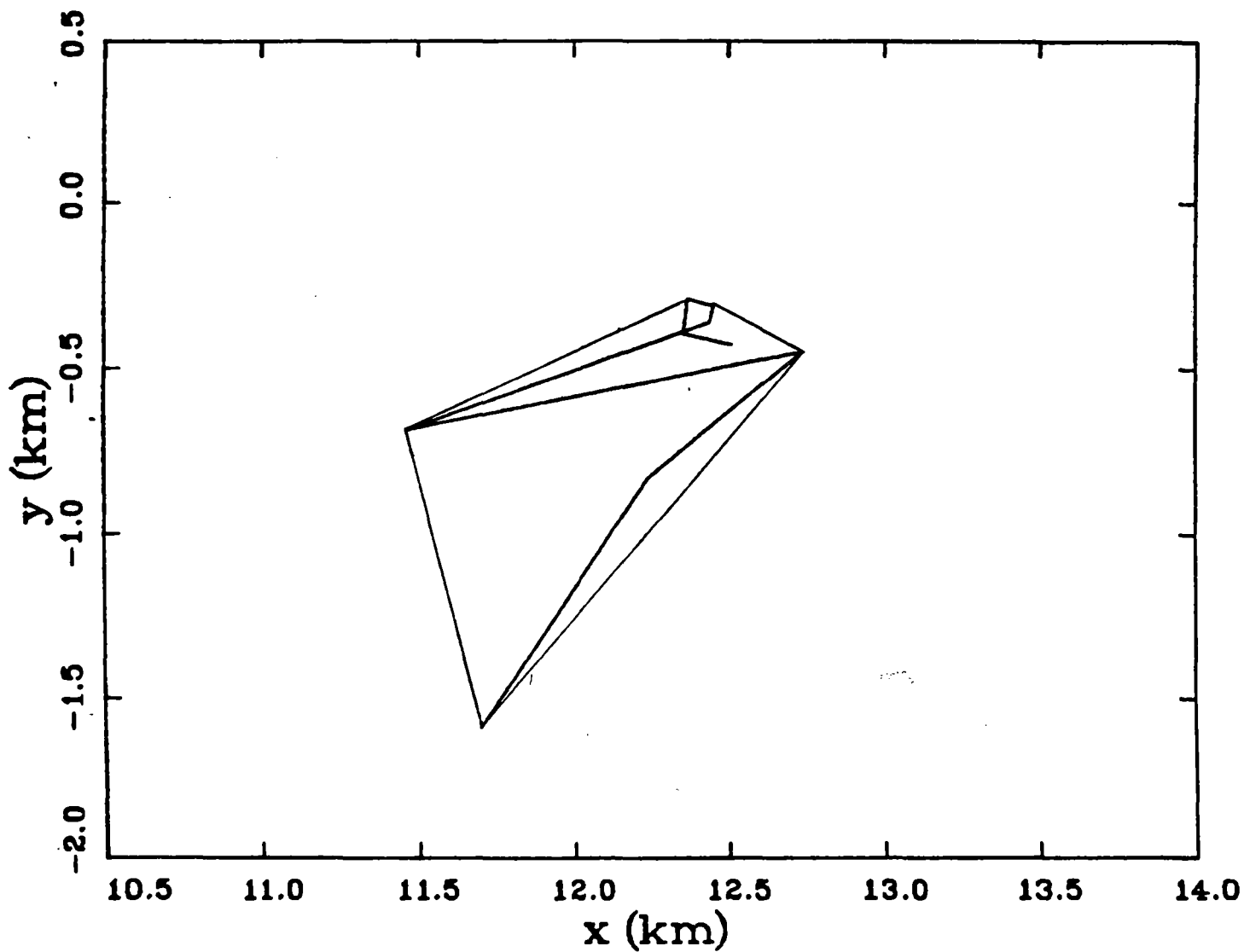


Figure 22. Computer generated map illustrating movement patterns of Bird 9 within its estimated home range. All fixes with an accuracy of 1 km are included. The outermost solid line is the home range boundary.

(Figures 14 and 15). This pair of Northern Goshawks nested in an active timber sale area on the Santa Fe National Forest. The areas not utilized by the pair have been heavily logged recently and may not support adequate prey populations. These were the only Accipiters monitored in an active logging area, so other similar comparisons cannot yet be made.

The movement patterns of Birds 4 and 8 presented in Figures 17 and 21 are examples of Accipiters with foraging areas confined predominantly to the drainage in which it nests. The east-west pattern of Bird 8's movements and the northwest-southeast pattern of Bird 4's movements correspond to the topography of their nest drainages. The drainages and their associated riparian vegetation are important foraging areas for Accipiters because these habitats support a diverse and abundant prey base.

HABITAT SELECTION FOR NESTING

Nest Tree Characteristics

Four Northern Goshawk and seven Cooper's Hawk nest trees were characterized. Three of the Northern Goshawk nests and four of the Cooper's Hawk nests were in Ponderosa Pine (Pinus ponderosa). One Northern Goshawk nest was in Aspen (Populus tremuloides), and the remaining three Cooper's Hawks nests were located in a Douglas Fir (Pseudotsuga menziesii), White Fir (Abies concolor) and Rio Grande Cottonwood (Populus fremontii). The pattern of nest tree species usage may reflect the availability of these tree species. A comparison of the proportion of each tree species available in the nest stands with the proportion used as nest trees will be conducted when the nest sample size is larger. Selection of particular tree species for nests by Accipiters has been documented in other studies (Moore and Henry 1983; Hall 1984).

The structural characteristics of the nest trees are presented in Figure 4. Tree morphology characteristics were not included in Table 4 because a suitable, quantitative method for analyzing the nest tree morphology from the photographs taken during the 1984 field season has not yet been incorporated in this study. Nest tree morphology results will be presented in subsequent reports.

TABLE 4

NEST TREE CHARACTERISTICS OF NORTHERN GOSHAWKS (N = 4) and
COOPER'S HAWKS (N = 7) IN THE JEMEZ MOUNTAINS, N.M.

<u>Characteristic</u>	<u>Goshawk</u>		<u>Cooper's Hawk</u>	
	<u>\bar{X}</u>	<u>S.D</u>	<u>\bar{X}</u>	<u>S.D</u>
Tree Height (ft)	107	22	79	29
Nest Height (ft)	71	15	54	25
Dbh (in.)	23	7	22	6

Nest heights of Cooper's Hawks were significantly lower ($P < 0.05$) than those for the Northern Goshawk. Position of the nest in the nest tree may be strongly affected by the height of the nest tree canopy. Northern Goshawks prefer to build below the crown in more exposed positions, while the Cooper's Hawk builds up in the canopy. In addition, Northern Goshawks, on the average, place nests in taller trees than do Cooper's Hawks ($P < 0.05$). However, there was no significant difference ($P > 0.05$) in the Dbh of the nest trees used by both species.

Nest exposure, in relation to tree bore, was examined to determine whether preferences existed for nest placement. Both species showed a random distribution of nest placement ($P > 0.20$).

The placement of the 11 Accipiter nests with respect to distance to a permanent water source and nearest human disturbance are presented in Figure 23. The nests of the two species were pooled to increase the sample size. The majority of the nests (7) were located 51 to 400 m from a permanent water source. Only one nest was located farther than 1 km from a permanent water source. We could not determine whether there was a significant preference for nest sites close to water, however, because we did not determine mean distance between randomly selected points and the nearest source of water in each nest area. We suspect, however, that the presence of water is an important factor in habitat selection by both Accipiter species.

All nests in this study were located in close proximity (25 to 400 m) to some type of regular human disturbance (present throughout most of the nesting season) (Figure 23). The types of disturbance varied e.g., recreation, logging, regular vehicular

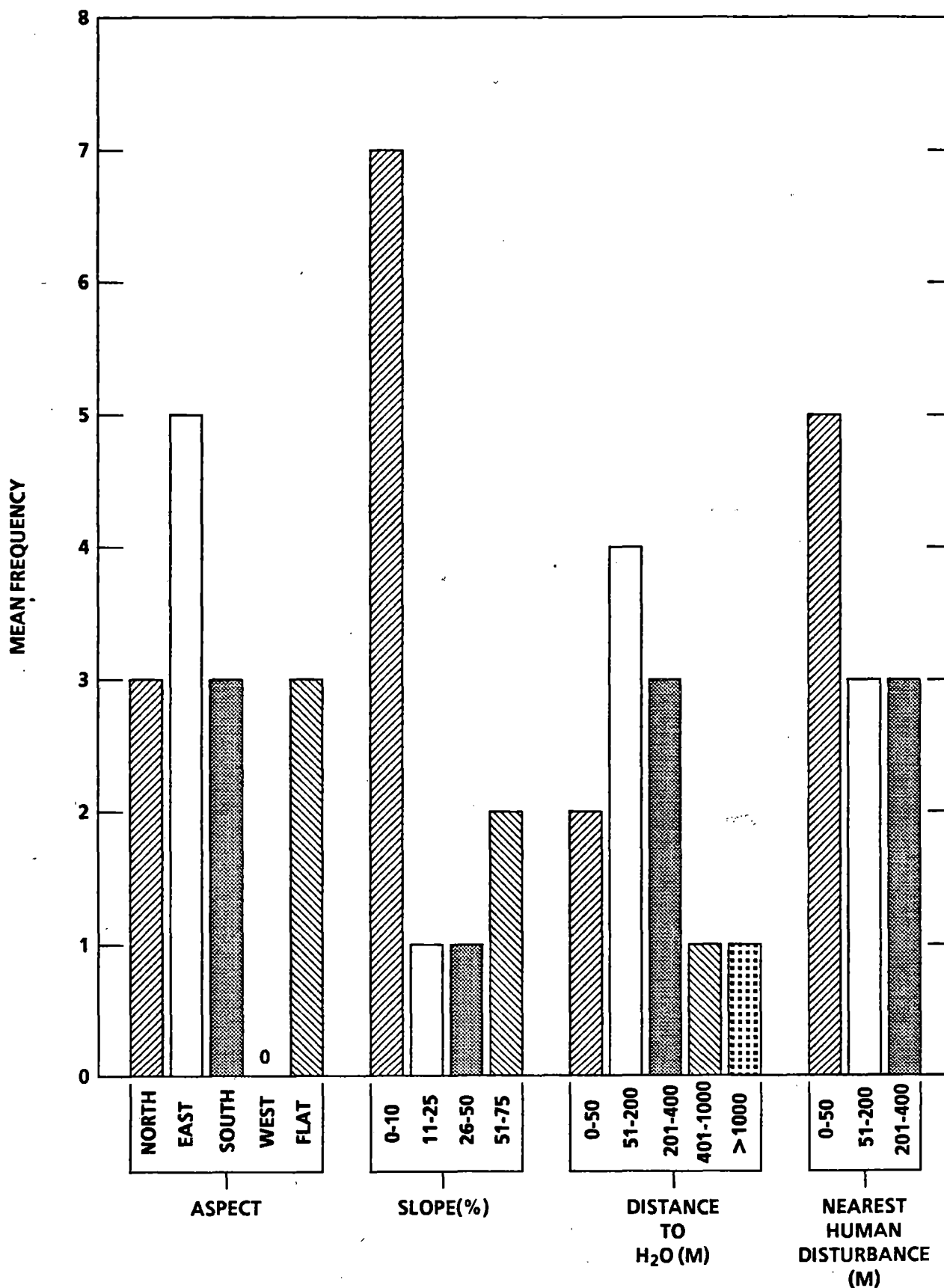


Figure 23. Placement of 11 *Accipiter* nests in the Jemez Mountains, NM with respect to stand aspect, slope, distance to water, and nearest human disturbance. North = 315 - 44°; East = 45 - 134°; South = 135 - 224°; and West = 225 - 314°.

traffic. There appeared to be a range in the individual tolerance levels of the hawks, as well as seasonal variation in the tolerance by a single individual. However, most of the nest sites had minimal human activity e.g., camping, picnicing, logging, during courtship and incubation, the periods with the highest risk of abandonment. It is possible that after hatching, these hawks can tolerate low-levels of regular human activity e.g., some vehicle traffic, hiking, camping in proximity to the nest (1/2-1 km). However, human disturbance <1/2 km from a nest should be avoided as a rule, because it regularly incites aggressive nest defense behavior in the adults. In addition, Snyder and Snyder (1975) found that juvenile *Accipiters* habituated to humans had a higher probability of getting shot than juveniles not habituated to humans.

Nest Stand Characteristics

The timber parameters of six Northern Goshawks and nine Cooper's Hawk nest stands were characterized. More nest stands than nest trees were examined because at four additional locations nesting was known to occur due to the presence of fledglings, but the locations were found too late in the season to identify the specific nest tree.

The aspect and average slope of the nest stands are presented in Figure 23. There appears to be no preference for site aspect except for avoidance of west-facing slopes. However, the selection pattern was not tested statistically. It is our impression that aspect was of minor importance in nest selection as long as a suitable nest tree and nest stand were present. Most nest stands (7) were located on slopes under 25%.

To evaluate the tree species composition of *Accipiter* nest stands, we pooled the number of trees of adequate size (>5 in. dbh) from the plots located in the stands of each *Accipiter* species. The proportion of each tree species within this pooled sample is presented in Table 5. Ponderosa Pine is the predominant tree in the nest stands of both species. Douglas Fir and Pinyon Pine (*Pinus edulis*) are the second most abundant tree in Northern Goshawk and Cooper's Hawk stands, respectively.

Some of the major differences between the tree species composition of Northern Goshawk and Cooper's Hawk nest stands are the proportions of Aspen, Cottonwood, and Oak sp. (*Quercus* sp.). Aspen represented 8.7% of the Northern Goshawk stands but no Aspen were found in Cooper's Hawk stands. Conversely, due to their association with

TABLE 5

TREE SPECIES COMPOSITION OF ACCIPITER NEST STANDS IN THE JEMEZ MOUNTAINS, N.M.^a

Tree Species	Northern Goshawk (N = 6) (%)	Cooper's Hawk (N = 9) (%)
Ponderosa Pine (<u>Pinus ponderosa</u>) ^b	58.3	48.2
Pinyon Pine (<u>Pinus edulis</u>)	6.7	14.0
Limber Pine (<u>Pinus flexilis</u>)	0.1	0.2
Douglas Fir (<u>Pseudotsuga menziesii</u>)	13.6	9.3
White Fir (<u>Abies concolor</u>)	4.6	4.8
Quaking Aspen (<u>Populus tremuloides</u>)	8.7	0.0
Rocky Mountain Juniper (<u>Juniperus scopulorum</u>)	2.7	5.2
One-seed Juniper (<u>Juniperus monosperma</u>)	5.0	5.4
Cottonwood (<u>Populus sp.</u>)	0.0	4.9
Gambel Oak (<u>Quercus gambellii</u>)	0.4	5.7
Oak sp. (<u>Quercus sp.</u>)	0.0	0.8
Misc. Hardwoods	0.0	1.4

a. This represents the proportions of each tree species from the pooled species composition of trees (Dbh > 5 in.) within all nest stands.

b. This includes the Yellowjack Pine.

lower elevation riparian habitats, Cottonwoods and Oaks comprised 11% of the Cooper's Hawk nest stands, whereas these trees only comprised 0.4% of the Northern Goshawk stands.

Frequency of dbh classes, total number of trees per acre, average basal area of the plots, mean tree dbh, (Tables 6 and 7) provide additional information on the vegetative structure of nest sites. The Northern Goshawk nest stands had significantly ($P < 0.05$) larger total densities of trees than the Cooper's Hawk stands. Higher densities were recorded in almost all dbh classes (Table 6). Results of similar studies indicate Northern Goshawk nests are typically located on sites with fewer and larger trees than those of Cooper's Hawks (Reynolds et al. 1982, Moore and Henry 1983). However, the results of these studies are based on much larger sample sizes than reported in these preliminary results. In addition, these studies were conducted in the Pacific Northwest where Cooper's Hawks are not nesting in Cottonwood/Willow river bottoms as they do in the southwest. Tree densities of Cooper's Hawk nest stands in this study area and in other southwestern locations may be lower on the average because of their use of these low density, riparian habitats.

Due to the higher average densities of the small dbh classes in the Northern Goshawk stands, the mean dbh for both live sound trees and cull trees were smaller than for the Cooper's Hawk stands (Table 6). The average basal area for Northern Goshawk stands is also higher than for Cooper's Hawk stands (Table 7).

As indicated by the data in Table 7, there is a lot of variation in the total timber densities, board ft/acre and ft^3/acre in *Accipiter* nest stands. Total densities of all live trees ranged from 620-5,870 trees/acre for Northern Goshawk and 1,200-5,440 trees/acre for Cooper's Hawks. Snag densities ranged from 0-15 snags/acre for Northern Goshawks and 0-9 snags/acre for Cooper's Hawks.

There is significantly more ($P < 0.05$) marketable timber in Northern Goshawk stands than in Cooper's Hawk stands, although there is a lot of individual variation between stands. The Northern Goshawk stands average 8,245 board ft/acre and 1,840 ft^3/acre of merchantable timber. The Cooper's Hawk stands average 5,645 board ft/acre and 4,480 ft^3/acre of merchantable timber.

TABLE 6

NUMBER OF TREES PER ACRE BY DBH CLASS IN ACCIPITER NEST STANDS IN THE JEMEZ MOUNTAINS, N.M.

Dbh Class (in.)	Northern Goshawk (N = 6)		Cooper's Hawk (N = 9)	
	\bar{X}	S.D.	\bar{X}	S.D.
<5.0 ^a	3,099.7	2,581.2	3,208.9	2,084.6
5.0 - 6.9	54.8	48.5	39.8	41.8
7.0 - 8.9	26.7	17.4	23.9	16.8
9.0 - 10.9	27.3	12.3	18.6	9.7
11.0 - 12.9	11.7	7.9	11.6	4.6
13.0 - 14.9	8.2	5.8	6.4	3.0
15.0 - 16.9	5.2	3.0	3.8	2.2
17.0 - 18.9	2.3	2.3	3.3	2.5
19.0 - 20.9	2.3	0.8	1.9	1.8
21.0 - 22.9	1.4	1.1	1.8	1.4
>23	3.7	5.7	1.9	1.5
Mean Dbh/Stand				
Live Sound Trees (all Dbh classes)	7.7	1.7	10.6	4.4
Live Sound Trees (>6 in. Dbh)	11.0	1.2	13.3	3.7
Cull Trees (all Dbh classes)	4.1	3.6	5.2	2.9
Cull Trees (>6 in. Dbh)	6.2	5.0	10.1	3.0

a. This includes shrubs, seedlings, and saplings.

TABLE 7

TIMBER STOCKING CHARACTERISTICS OF ACCIPITER NEST STANDS
IN THE JEMEZ MOUNTAINS, N.M

Tree Class	Northern Goshawk (N = 6)		Cooper's Hawk (N = 9)	
	\bar{X}	S. D.	\bar{X}	S.D.
Crop				
#/acre	174.0	70.7	107.4	82.6
bd ft/acre	497.7	311.0	414.8	379.8
ft ³ /acre	214.2	86.1	160.8	147.7
Excess				
#/acre	401.8	302.0	289.9	523.6
bd ft/acre	1,151.2	2,212.2	145.2	213.4
ft ³ /acre	377.5	597.7	97.9	112.3
Mature				
#/acre	35.8	36.2	19.6	17.1
bd ft/acre	6,595.7	6,120.7	5,084.3	4,368.0
ft ³ /acre	1,245.6	1,066.3	955.8	812.8
<u>Subtotal Merchantable Timber</u>				
#/acre	612.0	394.0	416.9	573.1
bd ft/acre	8,244.5	6,992.1	5,644.3	4,478.7
ft ³ /acre	1,837.5	1,406.2	1,214.5	908.5
Cull				
#/acre	2,630.8	2,599.7	2,904.6	1,812.7
bd ft/acre ^a	0	0	0	0
ft ³ /acre ^a	0	0	0	0
<u>Total Live Trees</u>				
#/acre	3,243.0	2,625.6	3,321.3	2,117.2
bd ft/acre	8,244.5	6,992.1	5,644.3	4,478.7
ft ³ /acre	1,837.5	1,406.2	1,214.5	908.5
Snags				
#/acre	4.5	10.1	4.6	4.8
bd ft/acre	378.5	861.8	227.7	438.1
BASAL AREA	94.1 ^b	38.6	67.6	19.9

a. The Santa Fe National Forest stand inventory analysis code only calculates bd ft/acre and ft³/acre for merchantable live and standing dead timber.

b. Basal area was only available for four Northern Goshawk nest stands.

REPRODUCTIVE BIOLOGY

Timing of Nesting

Clutch initiation for the Northern Goshawks (calculated by backdating from the date of fledging) ranged from May 1 through May 7. Clutch initiation for the Cooper's Hawk ranged from May 15 through June 1. The wider range in clutch initiation dates noted in the Cooper's Hawk probably results from the wider range of elevations at which it nests. Cooper's Hawks at the lower elevations (<7,000 ft) generally nested 1-2 wk earlier than Cooper's Hawks at higher elevations.

The nestling period was 30-34 days in both species. The fledglings at all nests were regularly recorded in the nest stand until the end of the field season (August 31, 1984). This can be interpreted as a minimum fledgling dependancy period of 30-45 days for the Cooper's Hawk and 60 days for the Northern Goshawk.

Nest Success

Sixty percent of all Northern Goshawk and 100% of all Cooper's Hawk nesting attempts were successful. The two Northern Goshawk failures were attributable to two different causes. One nest was struck by lightning, killing the young. The reason for the other nest failure is unknown. This pair acted as if they were going to nest (extensive courtship behavior observed) but they apparently never laid eggs.

The mean number of young fledged per nestling attempt was 1.4 for the Northern Goshawk and 3.0 for the Cooper's Hawk. No Northern Goshawk nestlings or fledglings were lost to predation, disease or starvation. However, one Cooper's Hawk nest lost two nestlings to unknown causes, and one nest lost one fledgling to unknown causes.

DIET COMPOSITION

During 1984, 37 and 30 items were identified from plucks and nest remains collected at six Northern Goshawk and nine Cooper's Hawk nest sites, respectively (Table 8). The prey items represented in the 150 castings collected during the nesting

TABLE 8

SPECIES IDENTIFIED AT ACCIPITER PLUCKS AND NESTS
DURING 1984 IN THE JEMEZ MOUNTAINS, N.M.

<u>Species</u>	<u>Common Name</u>	<u>Minimum Number of Individuals</u>
Northern Goshawk		
<u>Ceryle alcyon</u>	Belted Kingfisher	2
<u>Colaptes auratus</u>	Northern Flicker	9
<u>Nucifraga columbiana</u>	Clark's Nutcracker	2
<u>Cyanocitta stelleri</u>	Stellar's Jay	8
<u>Turdus migratorius</u>	American Robin	3
<u>Coccothraustes respertinus</u>	Evening Grosbeak	1
<u>Sylvalagus sp.</u>	Cottontail	5
<u>Sciurus aberti</u>	Abert's Squirrel	6
<u>Spermophilis lateralis</u>	Golden-mantled Ground Squirrel	1
Cooper's Hawk		
<u>Falco sparverius</u>	American Kestrel	1
<u>Columba livia</u>	Rock Dove	1
<u>Colaptes auratus</u>	Northern Flicker	8
<u>Sphyrapicus sp.</u>	Sapsucker sp.	2
<u>Cyanocitta stelleri</u>	Stellar's Jay	7
<u>Sialia currucoides</u>	Mountain Bluebird	2
<u>Eutamias sp.</u>	Chipmunk	7
<u>Sylvalagus sp.</u>	Cottontail	1
Unknown sp.	Snake	1

season have not yet been identified. Therefore, the diet composition data are biased in favor of the avian and mammalian prey which predominated at the plucks.

Sixteen different types of prey items have been identified. Of these, Northern Flickers (Colaptes auratus), Stellar's Jays (Cyanocitta stelleri), Cottontails (Sylvalagus sp.), and Abert's Squirrels (Sciurus aberti) were the most frequently encountered at plucks near Northern Goshawk nests. Northern Flickers, Stellar's Jays, and Chipmunks (Eutamias sp.) were the most frequently encountered prey items at Cooper's Hawk plucks. These preliminary results suggest that the mean prey size of Northern Goshawks is larger than the mean prey size of Cooper's Hawks but there is a lot of overlap in the prey taxa utilized by both species. In a recent study, Reynolds and Meslow (1984) found, in eastern Oregon where Cooper's Hawk and Northern Goshawk diets overlapped broadly in prey size, these species tended to take different prey taxa.

The utilization of similar prey taxa by the two Accipiter species in this study area suggest the common prey species, e.g., Northern Flickers, are not limiting in abundance and may be optimum prey items for both species due to their availability and size. Interspecific competition for prey may not be occurring between the Accipiters in this study area because food may not be limiting. However, this is purely speculative. Further dietary analyses may indicate prey size and taxa partitioning do occur between these sympatric species as well as between sexes within a species.

ACTIVITY PATTERNS

Timing of Flight Activity

Since Accipiters are strictly diurnal, activity was monitored only between 05:00 and 21:00 hr. The activity analysis focused on the two major activities related to hunting (prior to prey capture), flight and perching. Accipiters are known to forage by coursing below the canopy and flushing prey ("pursuit" predation). They also watch and listen for prey from perches ("sit and wait" predation).

Percent flight activity for Accipiters varied between species and within a species (Figure 24). Flight activity ranged from 4-14% of the daylight hours. Females averaged less flight activity than males during the daylight hours and Cooper's Hawks averaged

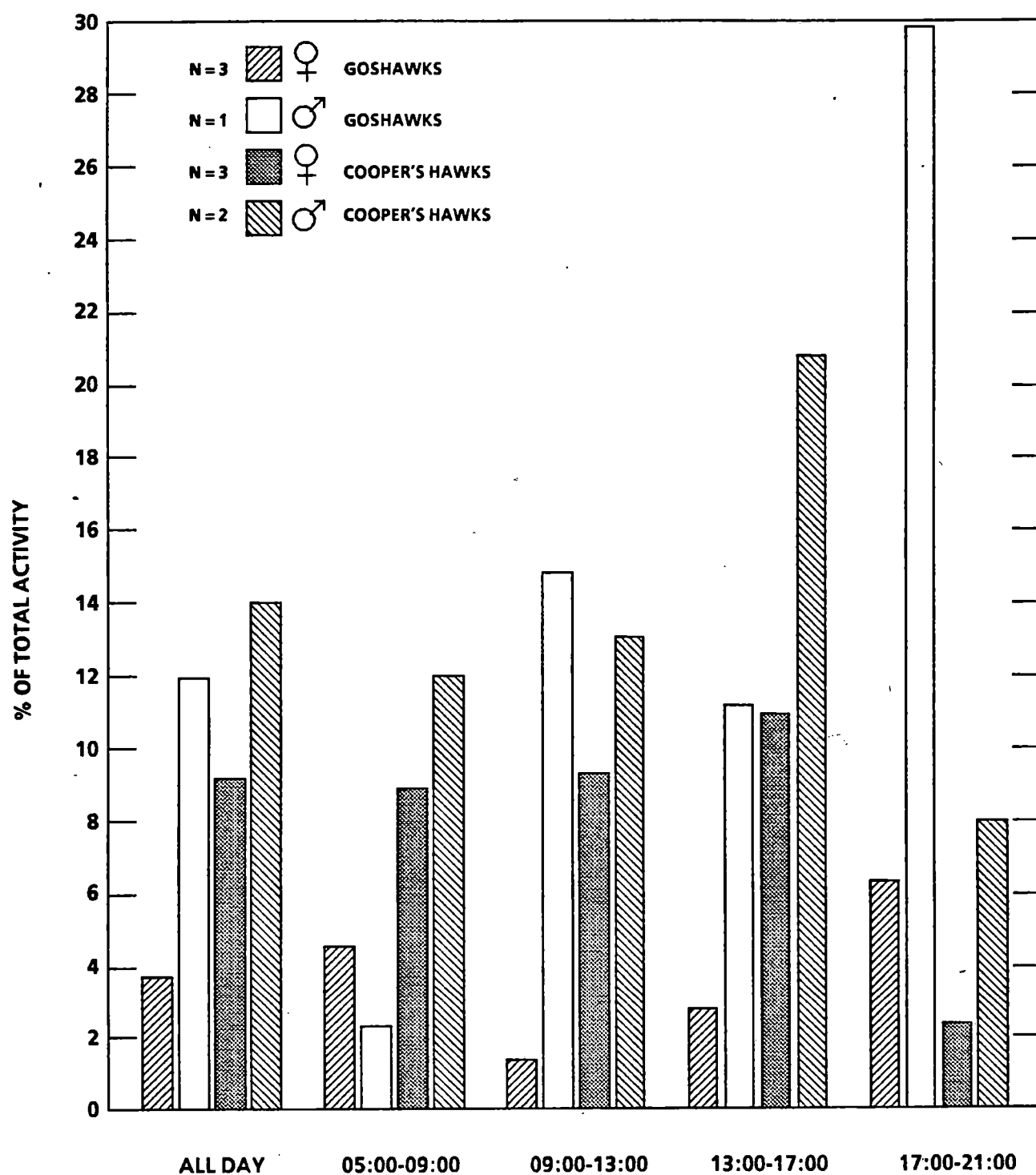


Figure 24. Total mean daily percent flight activity for radio-tagged male and female Accipiters. Vertical lines indicate \pm one standard deviation.

more flight activity than Northern Goshawks during the daylight hours. There was no difference ($P>0.05$) in the average percent flight activity at different times of the day for the females of both species. However, male Northern Goshawks were the most active in the evening (17:00-21:00) and male Cooper's Hawks were the most active in the late afternoon (13:00-17:00).

The fact that males spent more time in flight than females could result from a greater number of short flights and/or longer duration of flights. The mean length of time within one flight bout was significantly larger ($P<0.05$) on the average, for the one male Northern Goshawk than for the three female Northern Goshawks (Figure 25). However, there was no significant difference ($P=0.30$) in the flight duration of male and female Cooper's Hawks.

Only the female Northern Goshawks spent any length of time perching (Figure 26). Perch length time for Cooper's Hawks averaged 4 min. and for the male Northern Goshawk it averaged 8 min. Compared to activity studies on other raptors (Forsman et al. 1984), with the exception of the female Northern Goshawk, these Accipiters spend very short periods of time on a single perch; they are changing locations frequently.

Rate of Movement While Foraging

FIXX calculates the total straight line distance (km) between perch locations (path length) and the velocities (m/sec) of the birds traveling between perches. The total path lengths traveled by the radio-tagged individuals during the nesting season are presented in Table 9. The maximum velocity (V_{max}), total distance traveled at V_{max} and average distance traveled between perches is presented in Table 10.

The total path length traveled by an individual during the entire season ranged from 23-64 km (Table 9). Males of both species traveled greater total distances during the nesting season than did the females. In fact, the male Cooper's Hawks traveled greater total distances than did the female Northern Goshawks which are significantly larger birds.

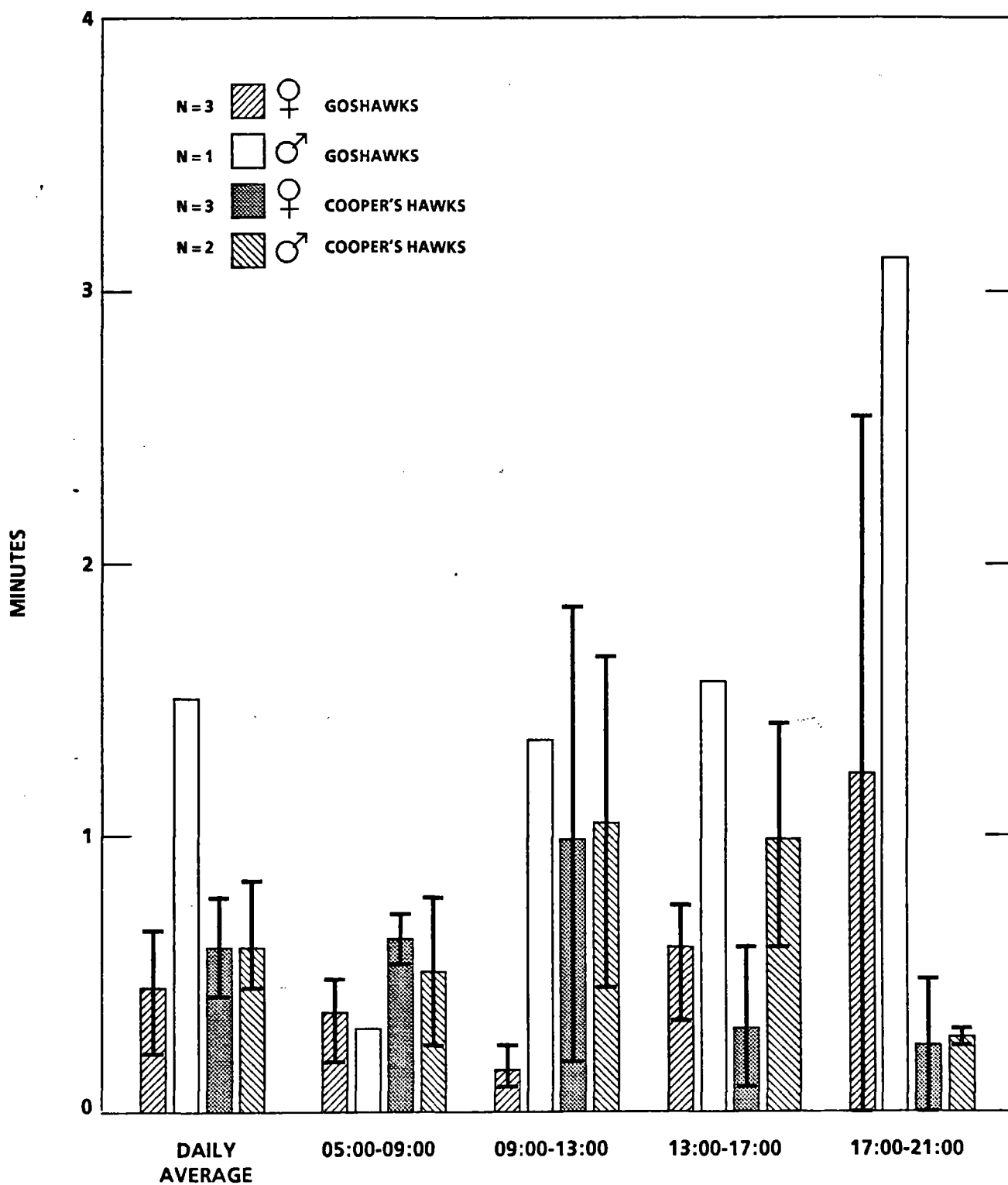


Figure 25. Mean length of time spent in flight, 4-hr diurnal time periods, for radio-tagged male and female Accipiters. Vertical lines indicate \pm one standard deviation.

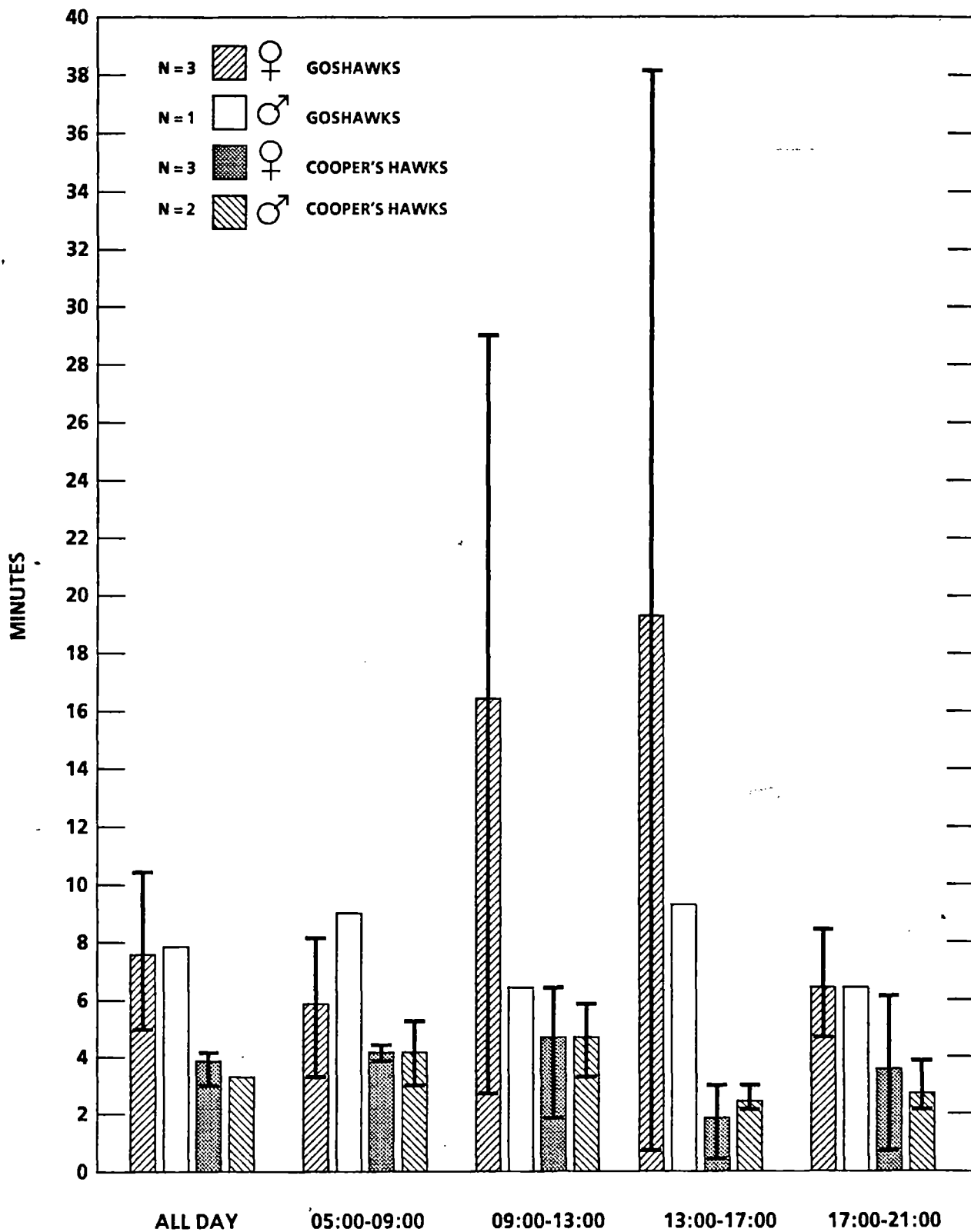


Figure 26. Mean length of time spent perching, by 4-hr diurnal time periods, for radio-tagged male and female Accipiters. Vertical lines indicate \pm one standard deviation.

TABLE 9

TOTAL PATH LENGTH (km) TRAVELED BY NORTHERN GOSHAWKS AND COOPER'S HAWKS
AT DIFFERENT STAGES OF THE NESTING SEASON^a

	Time Period ^b					Entire Season
	Early Nestling	Late Nestling	Early Fledgling	Mid Fledgling	Late Fledgling	
<u>Northern Goshawks</u>						
Bird 1 (M)	8.3 (0.5)	14.0 (1.0)	9.6 (1.0)	21.4 (1.9)	4.2 (0.5)	64.1 (2.7)
Bird 2 (F)	1.6 (0.1)	5.6 (0.5)	8.7 (1.6)	7.6 (0.9)	NA ^c	25.4 (2.1)
Bird 3 (F)	18.2 (1.8 ^d)	---	6.8 (0.4)	6.4 (1.3)	NA	35.8 (2.2)
Bird 7 (F)	NA	17.4 (1.5)	13.4 (1.7)	1.3 (0.5)	NA	32.4 (2.3)
<u>Cooper's Hawks</u>						
Bird 4 (F)	NA	3.4 (0.4)	12.0 (1.3)	10.1 (1.9)	NA	29.6 (2.4)
Bird 5 (F)	NA	5.9 (1.2)	4.8 (0.8)	11.5 (1.8)	NA	22.9 (2.3)
Bird 6 (M)	NA	14.4 (0.7)	10.8 (2.5)	14.4 (0.9 ^d)	NA	39.6 (2.7)
Bird 8 (M)	15.1 (0.4)	4.2 (0.7)	18.1 (1.8)	5.6 (0.8 ^d)	NA	50.8 (2.5)

a. Total path length is the sum of the total straight line distance calculated for each consecutive pair of radio fixes. The number in the parentheses is the total path length measurement uncertainty.

b. Each time period is an approximate 2 week period.

c. NA = Data are not available.

d. This represents the total path length for this time period and the subsequent time period. The two time periods were lumped due to small sample sizes.

Total path length is a function of the distance traveled while hunting and the number of trips an adult makes to the nest with prey, or other nest-related activities. The total path length of some individuals (Birds 1 and 7) decreased with time. However, most of the birds maintained a relatively constant path length over time or increased their total path length as the season progressed. The increased path length by the females probably corresponds with an increasing participation in hunting until the fledgling dependency period when the female is hunting as much as the male.

The average distance between perches for an individual bird ranged from 1.4 km for the male Northern Goshawk to 395 m for a female Cooper's Hawk (Bird 9). Our estimates of distances traveled between perches are undoubtedly high because accurate locations were not obtained for the perches used only for a few seconds. There was no significant difference ($P=0.15$) in the average distance between perches for males and females but the average perch distance for Northern Goshawks was significantly higher than for Cooper's Hawks ($P<0.05$).

The maximum velocities recorded for the birds ranged from 31.5 m/sec (70 miles/hr) for a male Cooper's Hawk to 2.0 m/sec (4.5 miles/hr) for a female Cooper's Hawk. The total distance each bird traveled at their maximum velocity ranged from 49 m at 2.0 m/sec (4.5 miles/hr) to 4.1 km at 12.9 m/sec (29 miles/hr). The male Cooper's Hawk (Bird 6) recorded traveling (or stooping) at a velocity of 31.5 m/sec sustained that speed for 0.6 km.

MANAGEMENT IMPLICATIONS

Because the Jemez Mountain Northern Goshawks and Cooper's Hawks may be vulnerable to changes in forest stands resulting from timber harvesting, to minimize the impacts to these nesting Accipiters the following recommendations are proposed. These recommendations are based on the results of this study and U.S. Forest Service published recommendations (Reynolds 1983).

- Uncut areas of approximately 6 and 8 ha should be left around active nests of Cooper's Hawks and Northern Goshawks, respectively. These areas should include portions of the stand upslope from the nest containing the plucking and roost sites, the nest, and some portion of the stream (if one is present). The contention is that the entire nest stand not just the nest tree is important in Accipiter nesting.

- Nest sites should not be isolated by silvicultural treatments such as clearcutting or total canopy removal. Areas adjacent to the nest site are utilized for hunting. Based on the nest stand results, a minimum live tree density of 618/acre and 1,204/acre needs to be maintained in the hunting areas adjacent to the nest sites for Northern Goshawks and Cooper's Hawks, respectively. This density should be maintained for a minimum 1 km radius around Cooper's Hawk nests and a minimum 2 km radius around Northern Goshawk nests.
- In areas where commercial thinning occurs, brush piles should be created to provide habitat for cottontails and chipmunks, common prey items of the Jemez Mountain Accipiters.
- A minimum of 4 snags/acre should be maintained at Northern Goshawk and Cooper's Hawk nest sites. To maintain these snag densities and brush piles, and minimize direct human disturbance near the nest, access to the timber harvest areas for fuelwood harvesting should not be allowed. Timber harvest areas near an Accipiter nest should not be closed to public access as soon as the timber harvest is completed.

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TABLE 10

MAXIMUM VELOCITY, TOTAL DISTANCE TRAVELED AT MAXIMUM VELOCITY, AND AVERAGE DISTANCE TRAVELED
BETWEEN PERCHES^a FOR NORTHERN GOSHAWKS AND COOPER'S HAWKS^b

	<u>V_{max} (m/sec)</u>	<u>Total Distance at V_{max} (m)</u>	<u>Avg. Distance (m) Between Perches^c (N)</u>
<u>Northern Goshawks</u>			
Bird 1 (M)	6.8 (0.8)	1,627.1 (194.9)	1,482.1 (318.1) (10)
Bird 2 (F)	4.4 (2.6)	528.1 (308.4)	771.1 (273.6) (10)
Bird 3 (F)	15.0 (1.7)	2,244.5 (254.1)	1,615.7 (178.2) (6)
Bird 7 (F)	12.9 (1.6)	4,084.8 (495.3)	1,342.7 (339.5) (15)
<u>Cooper's Hawks</u>			
Bird 4 (F)	3.8 (2.3)	282.4 (169.0)	936.1 (378.5) (6)
Bird 5 (F)	12.4 (4.5)	2,263.0 (820.3)	795.9 (273.0) (17)
Bird 6 (M)	31.5 (7.7)	567.0 (138.9)	808.1 (276.7) (20)
Bird 8 (M)	10.3 (1.4)	563.8 (76.7)	662.7 (130.2) (18)
Bird 9 (F)	2.0 (0.1)	49.5 (1.4)	394.3 (1.4) (3)

- a. This is the average measured distance between radio fixes of a bird. The radio fixes were always taken on perched birds. However, this number may overestimate the average distance traveled between perches because radio fixes were not usually obtained on birds perched for short periods of time (e.g., less than 2-3 minutes).
- b. The numbers in parentheses are the estimated measurement uncertainties (V_{max}) or standard deviations (total distance and average distance between perches).
- c. The average distance traveled between perches was calculated as the average distance between radio fixes with a measurement uncertainty less than 1 km and a calculated velocity of greater than 1 m/sec.

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